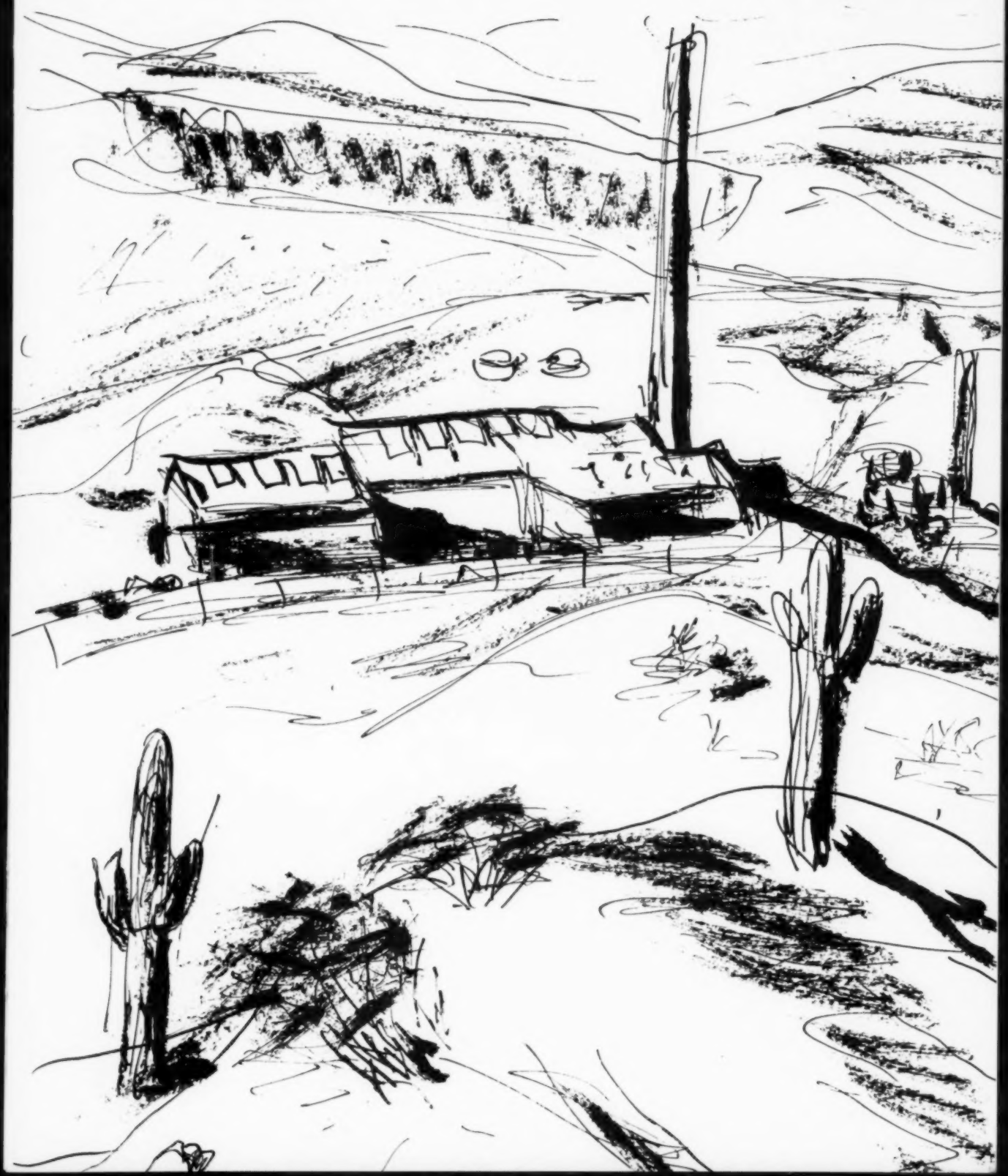
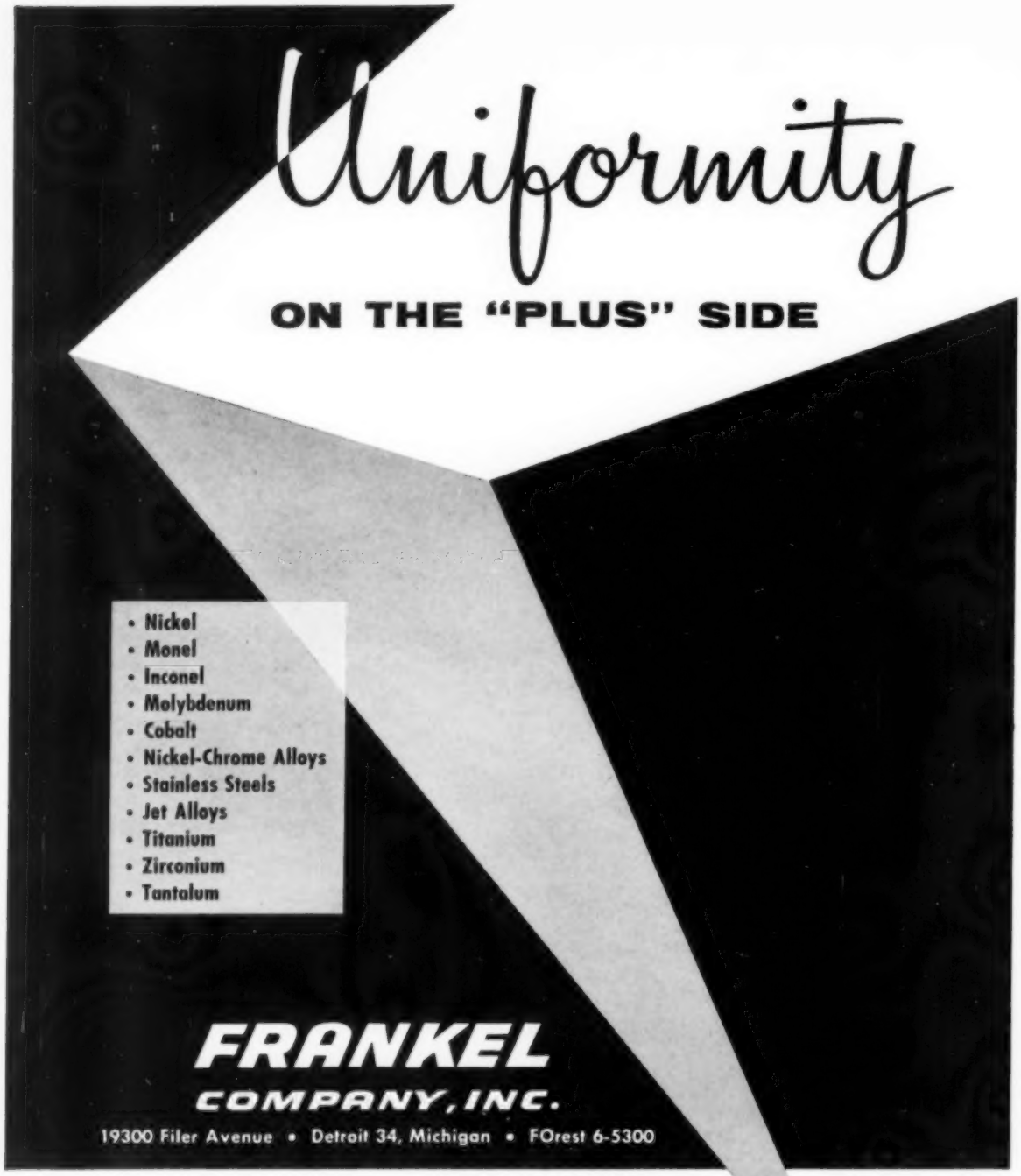
JOURNAL OF

METALS

JUNE 1959





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JOURNAL OF

METALS

Vol. 11, No.6
June, 1959

reporter 365
education 374
personnel 352
Personals 370
books 374
editorial 363
aime news 407
coming events 414
advertisers index 414

COVER:

America's newest copper smelter—Kennecott's Hayden, Ariz., plant—in its desert setting has been depicted by artist, David Cain. Details of this plant are given on p. 376, while its LPF unit is described on p. 382.

Indian National Research Laboratory Symposium 358

The New Hayden Smelter 376
by Ralph K. Johnson

Leach-Precipitation-Flotation Process 382
by M. W. Franz

1958 Income Survey of Members of The Metallurgical Society of AIME 386

The 1959 Nuclear Congress 391

What Happened in St. Louis? 394

The 42nd Conferences of the National Open Hearth Steel Committee and the Blast Furnace, Coke Oven, and Raw Materials Committee

Metals and X-Ray Emission Spectrography 398
by Herman A. Liebhafsky

Steelmaking/USA, Part III 403
by Leo F. Reinartz

CONTENTS: June issue of the TRANSACTIONS 372

EDITORIAL STAFF: Editorial Director, Rixford A. Beals; **Managing Editor,** F. Weston Starratt; **Associate Editor,** James J. Burke; **Production Editor,** Otto Johnson; **News Editor,** R. M. Schelkopf; **Editorial Assistant,** C. M. Cardon.
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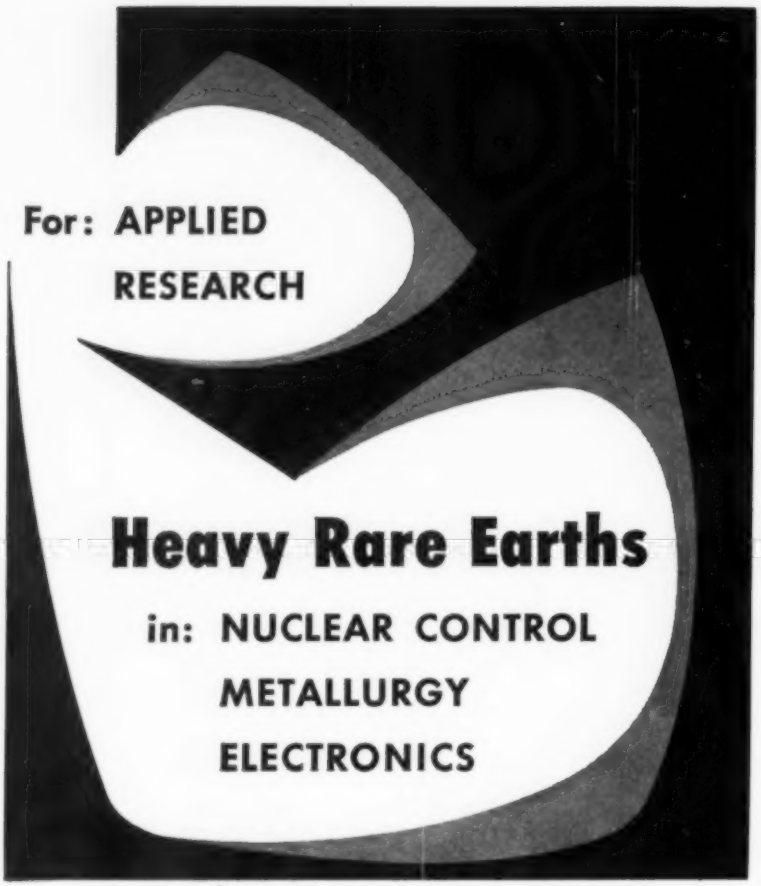

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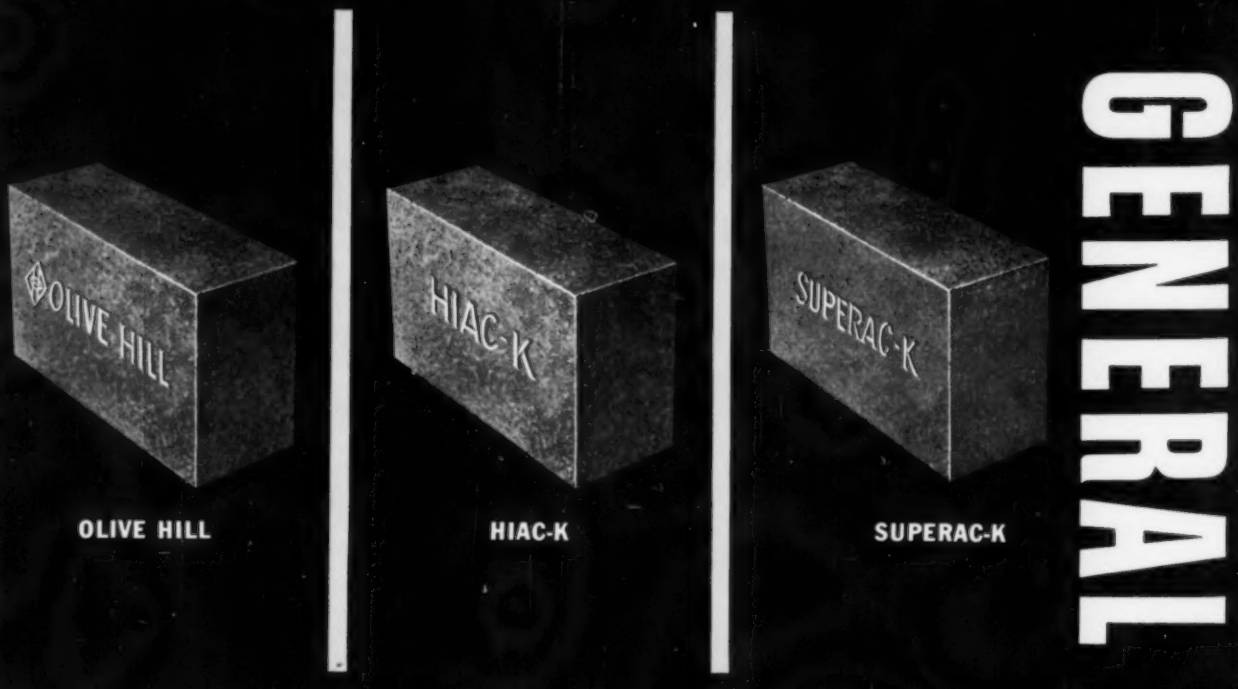
Director or Vice President, production sales and marketing, B.S. Met. Eng. Twenty years experience in metals industry manager posts; metallurgy, development, production, sales, and marketing. Ten year period in charge special metals; titanium, zirconium, hafnium, columbium, tantalum. Equivalent period, carbon, stainless steels and high temperature alloys. Prefer East. M-214.

Develop or Produce—Alloys, age 40, Met.E. (England), 3 years in charge of laboratory powder metals and surface films; 2 years developing and fabricating beryllium, nickel, manganese, copper, alloys; 5 months using vacuum techniques; 2 years research and development of new alloys for gas turbines, heat exchangers, tube production. $11,000. Desire West Coast. Home, Pa. M-1605

Process or Production; Age 33, MS ME, 2 years production planning, tooling control and design; 3 years process design machinery for production of mechanical and hydraulic test equipment; 2 years design tools for manufacturer; 1 year draft for research. $615. Prefer Foreign. Home, Wis. M-1508

(*Continued on page 354*)



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Personnel

(Continued from page 352)

Production or Quality Control; Age 34, Chemist six months evaluate missiles metals; 2 years preparation of aluminum billets for cold extrusion; 5 years precious metal refining and glass fiber production; 1 year aluminum smelters analysis. Desire San Francisco area. Home, Sacramento. M-1491

Production, Age 50, MS Met. E. Seventeen years quality control and processes for melting materials; 3 years automobile tool hardening; 2 years hardening furnace operator. Intermittent teaching of special and general metallurgy. $10,000. Desire South or West. Home Wis. M-1283

Production Planning or Sales, Age 39, ME plus Bus. Adm. Three years developing and producing new metal products for consumer and industrial use, managing and merchandising; 2 years plastic coatings; 6 years elevator sales, estimate, quote, survey, engineer and install. $650 up to start. Desire San Francisco or West Coast. Home, San Francisco. M-1250

Sales And Estimate, Age 34. Eleven years sales, estimates, buying, preliminary layout, installation supervision of sheet metal work on heat, air condition, refrigeration, plumbing, construction for contractors and shops. $650. Prefer San Francisco peninsula. Home, San Francisco. M-1215

Research Development, Production, Age 34, Met. E. Nine years Chief, quality, development, production, test procedures, customer contact in carbide industry; 3 years machining in carbides; 5 months plating and heat treatment; 2 years laboratory assistant, technician and library for university and Naval research. $9000. Prefer West, Home, Ky. M-1200

Layout Or Detail, Age 27. Five years preparing plans for shop and field for manufacture and installation of aluminum extruded or steel forming on window-wall layouts, doors, windows from architectural or strucutral drawings of public, commercial, industrial or residential buildings. $500 up. Desire San Francisco area. Home, San Francisco. M-1082

Foundry Engineering, Age 44. Chem. Met. (China). Ten years production, quality, cost on steel, cast iron, bronze, aluminum casting; 10 years assistant metallurgist in manufacturing in US and China. Salary, Open. Desire San Francisco; home San Francisco. M-1044

(Continued on page 356)

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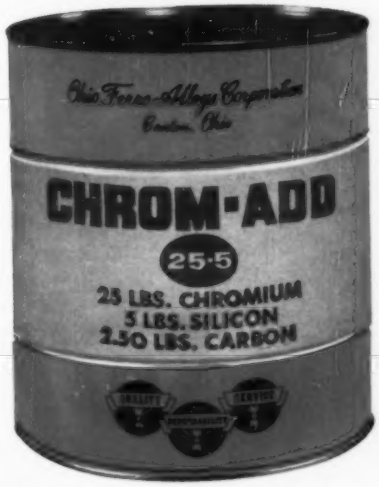

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Personnel

(*Continued from page 354*)

Plant Manager Or Chief Engineer, Age 40. ME. Three years advanced manufacturing development, process, machine tools and equipment for metals working, mining and petroleum industries; 3 years coordinating program and planning manufacture cars and trucks; 11 years industrial, development and factory Chief on automobile and aircraft parts. $17,000. Any location. Home, Mich. M-866

General Superintendent, Age 48, ME. Eight years in charge of production, forgings, weldments, pipe, couplings; 4 years charge of engineering, manufacturing, production of components for automobile supplier; 13 years branch office engineer for large steel producer; 5 years shipbuilding manufacture, chief engineer atomic bomb parts, research on magnesium alloys for manufacturer. $13,200. Any location. Home, Calif. M-313.

Research And Development, Age 39. BS Chem. Ph.D. Met. Twelve years industrial research in general applied metallurgy for a research foundation, including administration, hirings, salaries, personnel problems, and promotion of new work, sponsor contracts; 4 years analysing metallurgical field failures, production, troubles, quality control of raw materials. $13,000. Any location. Home, Chicago. M-1028.

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(*Continued on page 360*)

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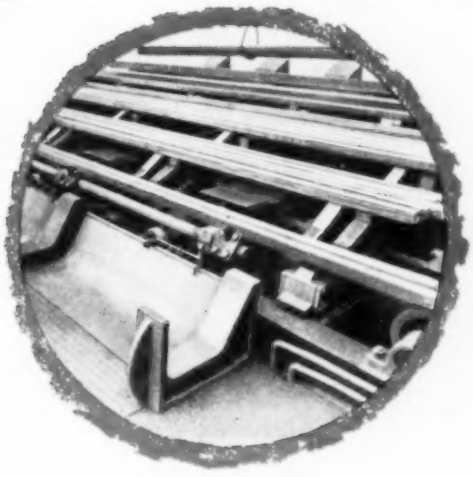

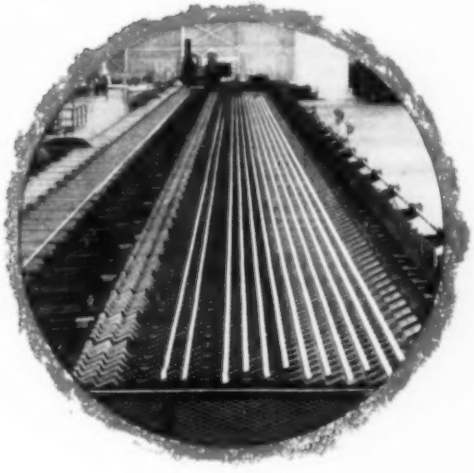

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INDIAN NATIONAL METALLURGICAL LABORATORY ORGANIZES SYMPOSIUM

A synopsis of the symposium on the "Iron and Steel Industry of India" held at Jamshedpur, India—compiled from the Technical Journal of the National Metallurgical Laboratory, February 1959.

FOCUSING attention on the latest developments in the iron and steel industry, a symposium on Iron and Steel Industry in India was organized by the National Metallurgical Laboratory (NML), Jamshedpur, India, from February 4th to 7th of this year.

Presenting the first paper of the symposium, Dr. Nijhawan summed up the role of National Metallurgical Laboratory in ferrous metallurgical research and development in India:

"Through India's iron ore resources are classic both in quality and reserves, resources of coking coals are far from satisfactory and, thus, alternative methods of using non-coking coals for iron production have to be investigated and developed. Although the potential coal reserves of India are estimated at 62,000 million tons, the reserves of known coking coals have been estimated at only 1500 million tons.

"The efforts at the National Metallurgical Laboratory have followed the old adage that limited objectives be chosen in the present context of our development. With the iron and steel industry, as in any metallurgical industry, one of the important themes of work would naturally relate to the raw materials involved in its operations.

Raw material reserves

India has vast deposits of high-grade iron ore, and beneficiation does not appear necessary in most cases, according to a paper by G. P. Mathur and P. I. A. Narayanan, National Metallurgical Laboratory. During mining operations, appreciable quantities of fines produced at present go to waste, but can be used profitably in blast furnaces after sintering. A detailed study for the Bhilai steel plant has been made on the sintering characteristics of iron-ore fines from Rajharapahar, Madhya Pradesh.

In connection with the utilization of the large deposits of low-grade magnetite from Salem, Madra, for starting an iron and steel industry in the south, the ore was successfully concentrated and its sintering characteristics were studied.

Although India has fairly large deposits of high-grade manganese ore, there are also many million tons of low-grade ore *in situ* as well as in dumps which cannot be utilized as such. On the basis of detailed ore-dressing investigations conducted in the Laboratory on nearly 30 different manganese ore samples collected from all over the country, it has been possible to classify Indian manganese broadly into four groups from the mineral dressing point of view, depending upon the nature of gangue associated with the ore minerals.

A low-temperature magnetising reduction roast process has been developed in the Laboratory for upgrading ferruginous manganese ores to make them suitable for production of standard-grade ferromanganese; pilot plant trials are in progress. Most of the Indian chrome ores may be characterized by their high iron content which, being present in chemical combination in the mineral chromite, cannot be reduced by ore-dressing methods to the specifications laid down for metallurgical purposes. Some chrome ores of Orissa have a favorable Cr:Fe ratio. Such ores should be conserved carefully for the metallurgical industry for production of standard ferrochrome.

Steel demand

Speaking on the *Trend of Steel Demand in India*, K.N.P. Rao, Tata Iron & Steel Co. Ltd., said "Since independence, and particularly after 1956, when the Second Plan was announced, the expansion of the steel industry has received considerable attention. The aim of the Government's industrial policy of 1956 is to accelerate the rate of economic growth by speeding up industrialization, particularly through the development of heavy industries."

Mr. Rao declared that a modest start to increase India's production to 6 million tons of ingot steel or 4½ million tons of finished steel has been made in the Second Plan.

"Considering the existing low per-capita consumption of about 10 lb," he continued, "the present target may be considered reasonable. Opinions have, however, been expressed that the expected output of 4½ million tons will not be readily absorbed with the present stage of industrial development and the state of the existing standard of living."

The estimated production capacity in India, as outlined by Mr. Rao, taking into consideration the steel plants under construction, is shown in the accompanying table.

(Text continued on page 366)

Estimated Production Capacity, Including Plants Under Construction, Millions of Tons

	Crude Steel	Finished Steel
The Tata Iron & Steel Co. Ltd.	2	1.50
The Indian Iron & Steel Co. Ltd.	1	0.80
Hindustan Steel (P) Ltd., Rourkela	1	0.72
Hindustan Steel (P) Ltd., Bhilai	1	0.75
Hindustan Steel (P) Ltd., Durgapur	1	0.75
Total	6	4.52

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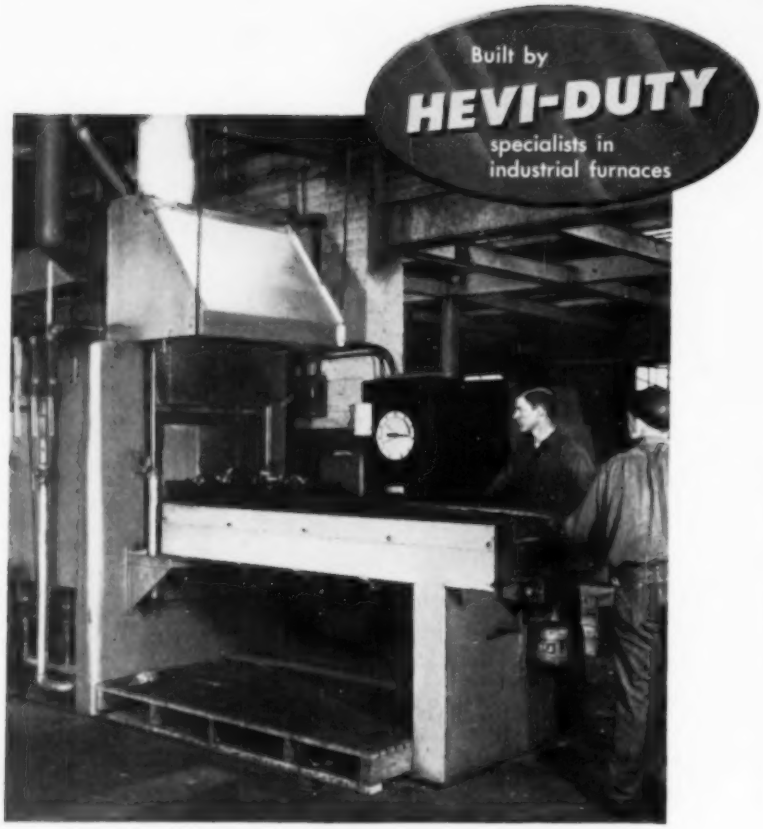

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- Industrial Furnaces electric and fuel
- Laboratory Furnaces
- Dry Type Transformers
- Constant Current Regulators

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Milwaukee 1, Wisconsin

Personnel

(*Continued from page 356*)

ment on ferrous and non-ferrous materials in connection with thermostatic, laminated or clad metals, electrical contact materials and special alloys. Will initiate, conduct and evaluate elevated temperature tests on such materials and develop variations to satisfy desired specifications. Salary, $6000-9000 year, depending on experience. Location, New Jersey. W7386.

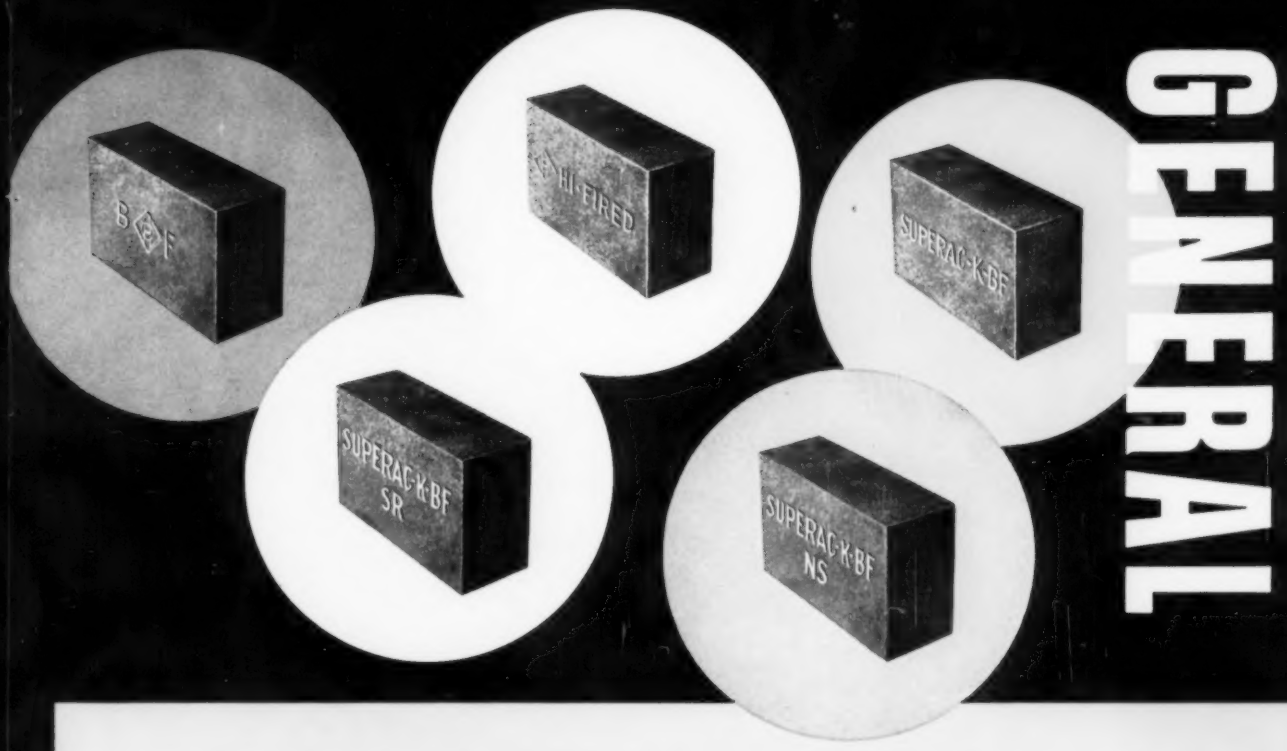
Sales Trainees, recent or near graduates in electrical, mechanical, or metallurgical engineering preferred, for national organization supplying materials and components to the electrical and automotive industries. Instruments, appliances and control devices—both thermostatic and electrical. Training and indoctrination period. Salary, $5200 year to start. Location, New Jersey. W7385.

Metallurgical Engineer, M.S. in metallurgy or metallurgical engineering preferred. To work in research department on research projects pertaining to elevated temperature, heat, corrosion and special analysis on steel castings. Must be able to follow through and direct research project. Minimum of three years experience in above work. Salary, $6600 year. Location, western Pa. W7359

Engineers, a) Supevisor of Testing: graduate engineer preferred with up to three years experience. To take charge of all testing aspects for newly established metallurgical research and development laboratory. b) Metallurgical Engineers with up to three years experience to fill recently created research and development positions. Conventional and advanced areas in reguline and powder metallurgy being investigated for private and government sponsors. Location, Long Island, N. Y. W7344

Metal Surface Research Engineers, non-ferrous metal. a) Recent Ph.D., physics or electro-chemistry, familiar with fused salt chemistry. Good experimentalist with interest in mechanism of fused salt-metal oxide reactions. b) Recent Ph.D. or equivalent in physical-surface chemistry. Research problems associated with surface reactions and oxide films. c) Project Engineer, Ph.D. or equivalent in chemical metallurgy or surface physics. Three or more years experience corrosion research with emphasis on metallurgical aspects. Responsible for major nonferrous corrosion research projects. Salaries, $7000-$10,000 year. Location, New England. W7186.

(*Continued on page 370*)



GENERAL REFRACTORIES

GREFCO OFFERS 5 SUPERIOR BLAST FURNACE BRICK

To meet the increasingly specialized demands of modern iron making, GREFCO now offers five different outstanding blast furnace bricks, each tailored to meet your requirements.

OLIVE HILL-BF—High duty fireclay brick for blast furnace linings. Now and for many years a standard of the industry.

OLIVE HILL HI-FIRED—Especially fired at high temperatures to combine the advantages of OLIVE HILL-BF with greater resistance to carbon disintegration.

SUPERAC-K-BF—The general purpose, high fired, superduty blast furnace brick having properties tailored to meet a variety of service conditions.

SUPERAC-K-BF (*SR*)—The high fired, superduty blast furnace brick with exceptional density, strength, and slag-resistant properties. Used frequently in bottom blocks and wearing plate areas.

SUPERAC-K-BF (*NS*)—The high fired, superduty blast furnace brick with exceptional resistance to spalling. Sometimes preferred for stack linings.

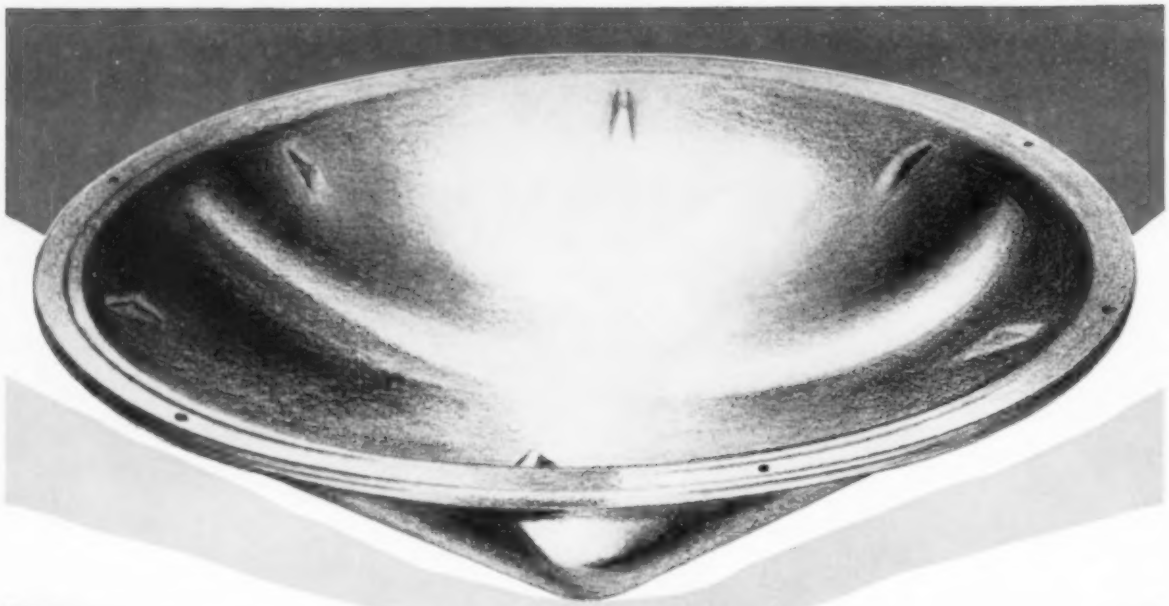
Your GREFCO representative will be glad to discuss with you the GREFCO blast furnace brick best suited to meet the conditions in your furnaces.

GREFCO

GENERAL REFRACTORIES COMPANY

PHILADELPHIA 2, PA.

A COMPLETE REFRACTORIES SERVICE



RE-ENTRY SHIELDS

EST. 1883

WYMAN-GORDON IS FORGING RE-ENTRY SHIELDS

- Copper in production
- Beryllium in limited production
- Reinforced plastics in development

WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

WORCESTER, MASSACHUSETTS

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DETROIT, MICHIGAN FORT WORTH, TEXAS LOS ANGELES, CALIFORNIA

EDITORIAL

Support for Process Metallurgy

The following material has been abstracted from a report prepared for the Materials Advisory Board. It indicates that a major area of metallurgical research is lacking much-needed financial support. It also indicates, at least by indirection, that schools and colleges are not turning out enough qualified people in this field, and that both industrial and educational laboratories that should have facilities for a balanced research program, do not. This could easily be framed as a "Which came first, the chicken or the egg?" question, but past experience has shown that an effort in either direction will go a long way toward providing a solution to the overall problem.—Editors

In any given field of science, it is important to maintain a proper balance among all types of research, from fundamental to applied, if the country is to realize the full benefits available from any particular piece of new knowledge. In the US today, a poor balance exists between physical metallurgy and process metallurgy.

For example, the metal beryllium has long been recognized as an element with attractively low density, but information on other properties was not available for a long time because the metal could not be isolated in adequate amount and purity. Additional years will be required before beryllium and its alloys will be available as a useful engineering material. Uranium, titanium, and zirconium provide similar examples. All required crash programs for their development, and the astronomical cost, inefficiency, and uncertainty of such efforts is well known. There can be little doubt that a coordinated research program would have reduced these time lags by a large factor. And even with the crash programs, there would have been much longer lags in development of these metals had not a concerted effort in the physical chemistry of steelmaking, begun in the early '30s, provided much valuable information on metal-oxygen reactions, vacuum treatment, and high-temperature technology.

This alarming lack of a continuing research program in process metallurgy is amply illustrated by AIME TRANSACTIONS. A spot check of vol. 209 reveals the following:

	No. of articles
Process metallurgy	
Iron & Steel Div.	13
Extractive Metallurgy Div.	21
Physical metallurgy	
Institute of Metals Div.	98

Ferrous and nonferrous process metallurgy thus amounts to only 26 pct of research reported in the volume. Two additional factors make this figure even more significant: of the 34 papers in process metallurgy, 12 (or 35 pct) resulted from work done in foreign laboratories; compared to 3 pct of the physical papers. Also, it should be noted that two other US journals, *Acta Metallurgica* and *ASM Transactions*, publish physical metallurgy exclusively. From this, some idea may be gained as to how great the imbalance is.

Industrial processes have tended to follow established patterns. Production methods for specific new metals have been developed by government support or pressure after the need for the metal has been etablished. Time lags are the natural consequence of such a limited approach. Most agencies supporting research have aggravated this imbalance by limiting such support to work dealing directly with end-product items, and this generally means physical metallurgy only. People interested in process metallurgy in both academic and industrial environments are familiar with the appraisal of a proposal as scientifically meritorious, but lacking financial support as it is not directly related to end-product items. This has created a situation which should be carefully examined, for as a review of the abstract services show, our national competitors have not allowed this to happen.

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Conquest of the Thought Barrier

Over the years, we have been hearing of many "barriers" in science . . . the sound barrier, the water barrier, the thermal barrier.

Of all the barriers, the hardest one to break through has always been the thought barrier. Every one of these "barriers" has been conquered by men to whom the word, impossible, means only: "hasn't been done, *yet*."

The sound barrier is a shattered concept, as discredited as the phlogistic theory.

Don Campbell's *Bluebird* stopped all talk of the water barrier.

The heat of air friction against the metal "skin" of an airplane was supposed to create a heat barrier at Mach 3. Materials now in production can safely withstand the much higher temperatures involved in flight at Mach 5.

Today the thermal barrier is being called the "thermal thicket"—evidence in itself that no barrier exists.

An interesting point that all of these "barriers" have in common: each was conquered with the help of nickel-containing alloys.

This is not surprising when you stop to consider how many useful properties and combinations of properties are offered by the various nickel alloys:

Corrosion resistance to a wide variety of solids, liquids and gases . . . strength at high temperatures . . . toughness at sub-zero temperatures . . . unusual electrical properties . . . ability to protect product purity . . . spring properties . . .

When you are faced with a metal problem, investigate Nickel and its alloys. There is a good chance some nickel-containing alloy will help you break through what others consider a thought barrier.

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

New ductile iron alloy available

A new-high magnesium silicon-base alloy that allows more efficient ductile iron production is now available. The announcement was made recently by its supplier, Union Carbide Metals Co., div. of Union Carbide Corp.

Called "EM" Alloy 55, the new material contains 30 to 32 pct Mg, 50 to 55 pct Si, 4 to 5 pct Ca, and 1 pct mischmetal.

Treatment with the alloy is carried out by the new plunging technique. In this the alloy is placed in a refractory basket and plunged into a ladle of iron. The magnesium vaporizes and bubbles up through the metal. Enroute it is absorbed by the iron, giving ductile iron the composition needed for its unique properties.

Almost twice as much magnesium is recovered compared to conventional open-ladle treatments with more dilute magnesium alloys. Plunging also eliminates most of the dross formed by oxidation of magnesium. A suitable plunging device is a refractory bell attached to a shaft and cover. The alloy is generally placed in a light-gauge steel can and held inside the bell by rods or heavy wires.

Molybdenum metal powder process

The invention of a new process for the production of molybdenum metal powder by a rapid, single-stage reduction of molybdenum oxide at high temperatures has been announced by Metals & Residues Inc., Springfield, N. J.

B. H. Davidson, technical director, estimated that the single-stage reduction process increases the rate of molybdenum power production by a factor of 5 to 8 times over the rates obtainable by current practices.

Dravo gets US Kaldo rights

Dravo Corp. has acquired marketing, plant design, and construction rights for the Kaldo process in the US and Canada.

The Swedish oxygen steelmaking process, developed by Stora Kopparbergs Bergslags Aktiebolog, features the use of an inclined, variable-speed rotating furnace for the reduction of pig iron to steel. (See JOURNAL OF METALS, July 1957, pp. 972 to 975.)

Although the Kaldo process was developed primarily for the production of steel from Sweden's high-phosphorous iron ore, its ability to produce top quality steel in a broad range of specifications from low-phosphorous iron has been proved.

Based on operating experiences at the Swedish company's Domnarvet works, it is estimated that a Kaldo installation in this country or Canada will cost between 50 and 65 pct less than a new open hearth shop with similar capacity and auxiliaries.

Find hi-temp Columbium alloys

A series of Columbium-base alloys, characterized by high temperature strength, has been developed by Fansteel Metallurgical Corp.

Two of these alloys, Fansteel 80 and 82, are now commercially available.

Fansteel 80 is a columbium-zirconium combination, with a melting point of 4350°F, and a density of 8.6 g per cu cm.

Fansteel 82 is a columbium-tantalum-zirconium alloy. Its melting point is 4550°F, and its density 10.26 g per cu cm.

Both alloys are easily fabricated at room temperature, either in the as-worked or annealed state. Both have excellent weldability with ductile welds, and little or no tendency to fracture in the heat-affected zones.

Fansteel 82 has high resistance to oxidation, as compared to the pure refractory metals. Moreover, the oxide film is tenacious and non-volatile, and tends to form a protective coating. In air, the 82 alloy has an ultimate tensile strength of approximately 30,000 psi at 2000°F. The 10-hr stress-to-rupture strength at 2000°F is 26,000 psi.

The 80 alloy has properties generally comparable to Fansteel 82, with the advantage of a higher strength-to-weight ratio. Its oxidation resistance is comparable to that of pure columbium.

Both alloys are now made in 4 in. diam ingots.

Siberia yields industrial diamonds

It has been said that the only industrial mineral and ore lacking in the Sino-Soviet bloc is industrial diamonds. This may no longer be true!

According to an article in the Communist Party organ, *Pravda*, in seven years the Yakut Autonomous Soviet Republic in Siberia "will become one of the largest centers of the diamond industry in the world, increasing the world's supply of this valuable mineral 15 to 16 times."

Thermoelectric matter discovered

An important step in the development of thermoelectric materials for the direct conversion of heat into electricity at high temperatures has been made.

Scientists at the Westinghouse Electric Corp. Research Laboratories, Pittsburgh, Pa., have discovered a thermoelectric material for use in the temperature range from 850° to 1500°F.

The new semiconductor material—indium arsenide phosphide—is designed solely for thermoelectric purposes. The three-element compound is reported to be the most efficient of its type yet discovered. It was prepared by chemically combining high-purity indium with pure arsenic and phosphorous.

REPORTER

PLAIN FACTS ABOUT THE SOCIETY

1 The Metallurgical Society of AIME is continually planning a program of more and better services for all its members.

2 This program requires substantial membership growth, since the cost of providing services to each member decreases with increased membership.

3 There is a known potential for such an increase among all types of Metals Men now served by the Society through its various Divisions.

4 A great number of qualified persons have not joined The Metallurgical Society simply because they have never been invited to do so.

Conclusion: YOU will benefit from the program to increase and improve services, but only if YOU are personally active in the drive to obtain new members. No new members, no new services; its as simple as that.

Action Required: Ask at least one nonmember colleague to join The Metallurgical Society within the next 30 days. If unable to make a personal contact, use the form on last page to propose a qualified Metals Man for membership.

This badge identifies professional Metals Men Wear it with pride!

THE METALLURGICAL SOCIETY OF AIME
29 West 39th. Street New York 18, N. Y.

Indian Symposium

(Continued from page 358)

"Back-yard" furnaces considered

Dr. Nijhawan also reported that a cottage scale steel industry for fabrication of small agricultural and other tools has been studied at NML. In the process, developed, crushed ore is packed in a paper tube which is embedded in charcoal, the whole being placed in a steel container. This is placed in a kiln, similar to those used in brick-making, and held several hours at 1100°C, while sintering and reduction take place. It is reported that a fairly compact steel bar results, under proper conditions, which may be readily hot worked.

LD semi-pilot plant

"A basic lined converter having a capacity of treating 250 lb of molten metal per heat has been designed and fabricated in the National Metallurgical Laboratory to study the possibilities of refining high-silicon-medium phosphorus, Indian pig irons to desired grades of carbon steel by oxygen [LD] steelmaking processes. By adopting a specially timed double slagging technique, adjusting the oxygen flowrate at 10 cu ft per min per cwt metal, and simultaneously controlling the temperature by addition of limestone/lime and iron ore/mill scale, assisted by suitable arrangements of oxygen tip position on the buffer slag zone during the second stage of lancing (after removing the siliceous slag in the first stage), results have been obtained from Indian pig irons with an average composition of 3.5 to 4.0 pct C, 1.5 to 2.0 pct Si, 0.35 to 0.4 pct P, and 0.035 to 0.04 pct S."

Low-shaft pilot plant

"Work on Low-Shaft Pilot Plant Project is expected to start shortly. This pilot plant has been set up by the National Metallurgical Laboratory in collaboration with the Metals Committee of Council of Scientific and Industrial Research. [This plant was inaugurated during the meeting.]

"Our plant has a production capacity of 15 tons of pig iron per day and will be able to treat different inferior grades of raw materials. The object of the comprehensive investigations is to assess the possibilities of making commercial grades of pig iron with raw materials like soft iron ore, iron-ore fines, beneficiated magnetite iron ore, with various non-coking high-ash coals or carbonized lignite, plentiful supplies of which exist in India but are unsuitable for exploitation in conventional blast furnaces. The results of these extensive investigations will be of great value and will enable the establishment of small units for iron and steel production in different parts of India.

"The 15 tons-per-day low-shaft furnace pilot plant, supplied by the Demag-Humboldt Niederschachtofen, Duisburg, West Germany (see JOURNAL OF METALS, November 1957, p. 1432), operates on iron ore, limestone, non-coking briquettes. The daily operation of the plant needs over 100 tons of raw materials.

". . . during the period following the establishment of this Laboratory, progress in research in many fields of iron and steel metallurgy has been steady and rewarding, placing a high premium on ingenuity, scientific research, and development work."

Lectromelt-Demag

electric smelting furnaces

Now...world-famous
Demag design
built by Lectromelt*
Pittsburgh, U.S.A.

Demag design has no equal for smelting operations . . . and now these way-ahead furnaces are constructed for you by Lectromelt, America's outstanding producer of electric furnaces. The unmatched Lectromelt-Demag combination of skills affords new highs in smelting efficiency, economy and safety.

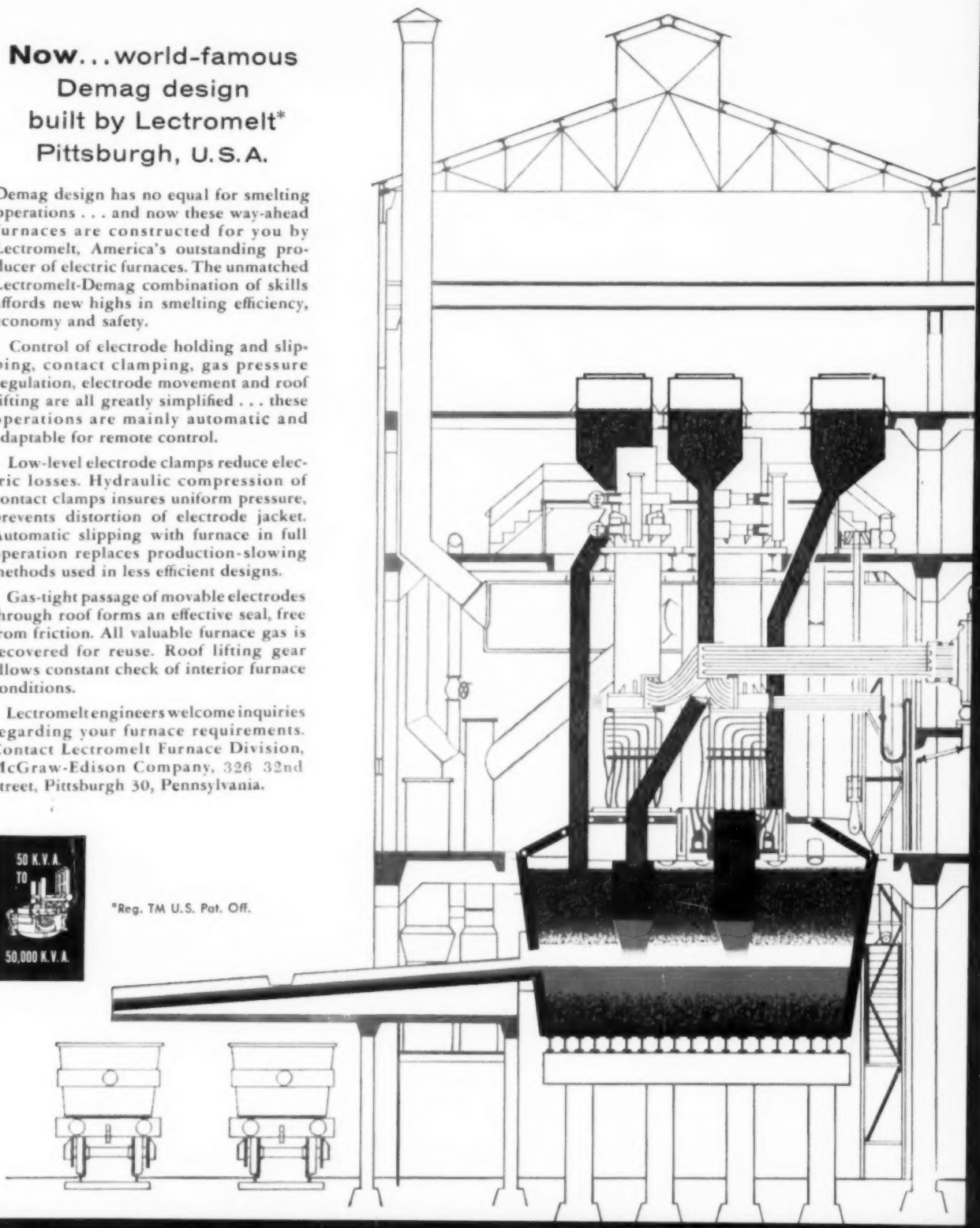
Control of electrode holding and slipping, contact clamping, gas pressure regulation, electrode movement and roof lifting are all greatly simplified . . . these operations are mainly automatic and adaptable for remote control.

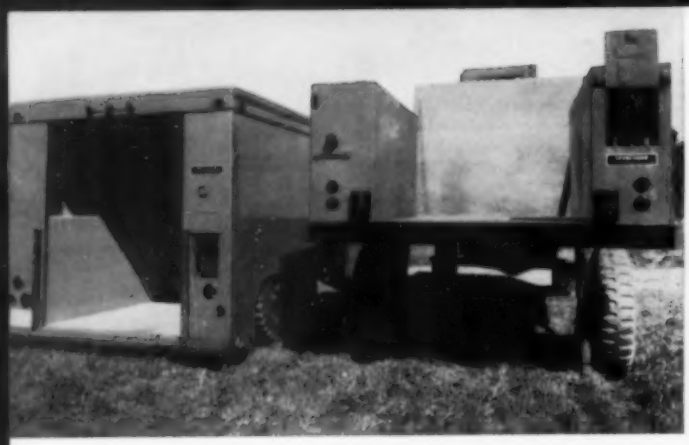
Low-level electrode clamps reduce electric losses. Hydraulic compression of contact clamps insures uniform pressure, prevents distortion of electrode jacket. Automatic slipping with furnace in full operation replaces production-slowing methods used in less efficient designs.

Gas-tight passage of movable electrodes through roof forms an effective seal, free from friction. All valuable furnace gas is recovered for reuse. Roof lifting gear allows constant check of interior furnace conditions.

Lectromelt engineers welcome inquiries regarding your furnace requirements. Contact Lectromelt Furnace Division, McGraw-Edison Company, 326 32nd Street, Pittsburgh 30, Pennsylvania.

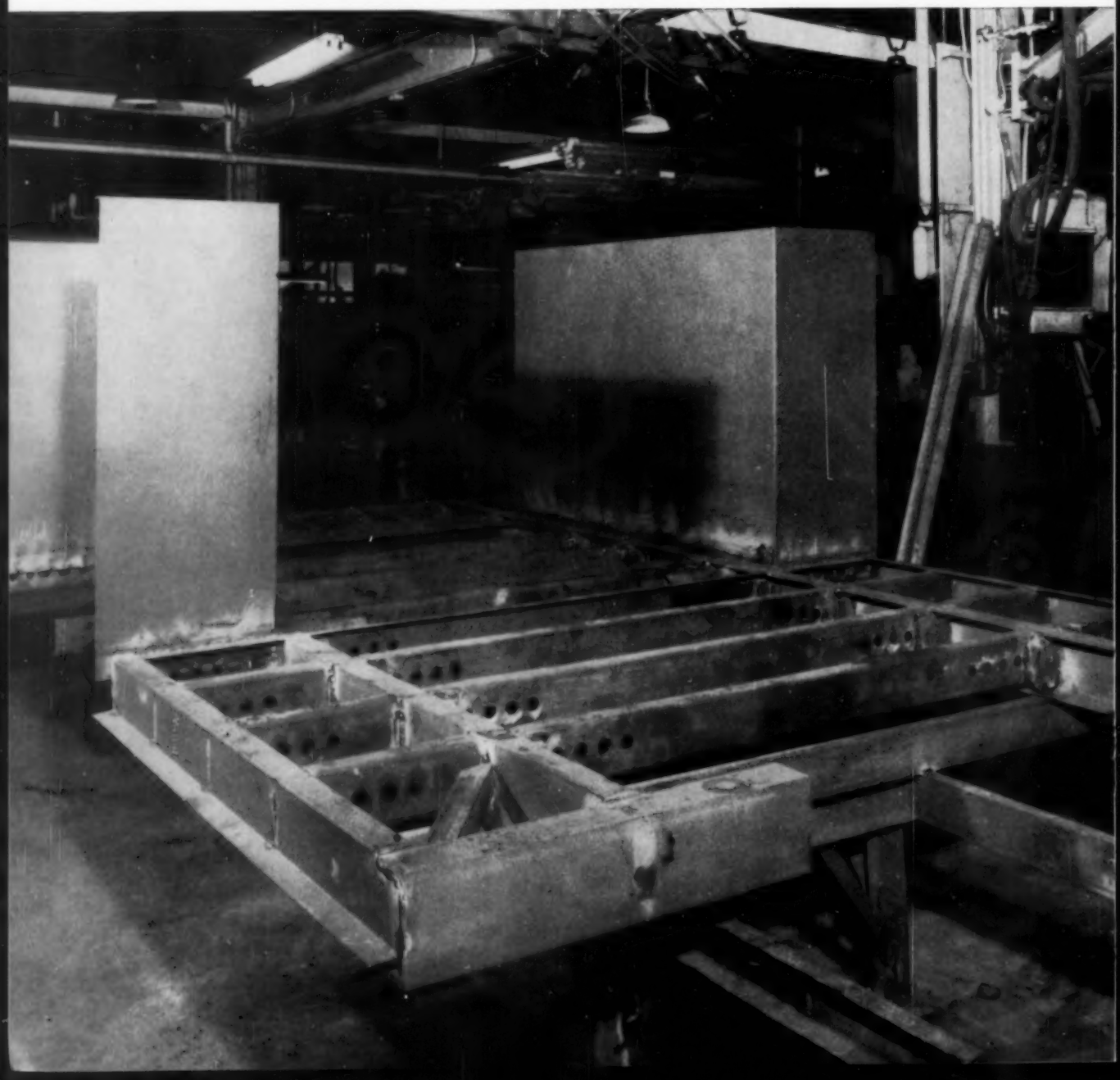
*Reg. TM U.S. Pat. Off.





The Thompson Level-Loder raises and lowers to any height from curb side to 4½ feet. Hydraulic cylinders lift the body up and down in a vertical guide mounted on the truck cab. Thompson Trailer Corp., Pikesville, Maryland, a subsidiary of General American Transportation Corp., Chicago, introduced the new design.

It tilts . . .



. . it leans . . . . . it hunches up and down

Unique truck built lighter, stronger with USS COR-TEN Steel

Here's a truck body that acts like an elevator. With front wheel drive, it has no rear axle or drive shaft. Hydraulic cylinders tilt it forward, backward, sideways, and raise it up and down to any height from curb level to 4½ feet. This cuts loading time as much as 75% and makes unloading up to five times faster.

Because the main stress of the lift is concentrated at the wheel box housings, they have to be as strong as possible. And because the truck body is lifted along with the payload, the body has to be as light as possible. The entire body, including the wheel housings, was built with USS COR-TEN High-Strength Low-Alloy Steel because this grade meets the demands of both lightness and high strength. COR-TEN Steel's 50% higher yield point means it can be used in thinner and lighter gages, reducing weight as much as ⅓ with no sacrifice in strength. And it has high resistance to abrasion, atmospheric corrosion, impact and fatigue.

U. S. Steel produces three brands of High Strength Steel—COR-TEN, TRI-TEN, and MAN-TEN. Each has characteristics that make it ideal for special design applications. For complete information about these "steels that do more", write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. *USS, COR-TEN, TRI-TEN and MAN-TEN are registered trademarks*

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

Personnel

(Continued from page 360)

Physical Metallurgist, non-ferrous laboratory. Ph.D. or equivalent, with two years research and development experience in physical metallurgy of copper and aluminum base alloys. Alloy development experience desirable. Position with research laboratory. Salary, $7000-$10,000 year. Location, New England. W7187.

Process Metallurgist, non-ferrous. Ph.D. or equivalent in physical metallurgy, with experience in copper and/or aluminum alloys. Two to four years experience in melting and casting required. Continuous casting experience desirable. Position with research laboratory. Salary, $7300-$11,000 year. Location, New England. W7188.

Designer—Steel Mills, minimum 15 years complete steel mill design, including at least 3 years actual work in steel operations, and several years top project engineering level working with management, client, design department. Must now be working on design layout of blast, open hearth, oxygen lance and main equipage—including equipment and building layout. For engineering builder. Relocation and placement fee paid by employer. $15,000 level. Apply by letter in confidence. San Francisco. S-4277.

Tester—Metals Coatings, recent graduate or previous laboratory experience. Make tests on light sheet metal, platings or organic coatings, including performance, corrosion, life, and comparisons on new products, processes, and materials. Container manufacturer. $450. San Francisco. S-4250.

Research—Refractory, BS or MS, preferably with knowledge of powdered metals. Qualified to deal with challenging metallography and metallurgical laboratory studies relating to new product development of refractories. Knowledge of physical chemistry, able to use advanced laboratory equipment, testing and instrumentation and with an interest in electrolytical process development. $650-750 up. Central Calif. Coast. S4142.

Development—Non Ferrous And Alloys, Met. with 3 to 10 years experience in physical metallurgy, preferably in non ferrous metals and development of new alloys; x-ray defraction experience desirable. For a consultant. $700-950. San Francisco. S-4188.

Development, Operations—Lead, Met. or ChE. Experienced in or demonstrated aptitude for development, research, or operational work in connection with lead smelting. $500 or more. Midwest. S-4181.

Sales—Basic Metal, graduate. Young, 1 or 2 years out of school. To train with a large producing company for sales engineering work relating to the use, application and sale of base lead to large industrial and manufacturing users. $600 or so. Midwest. S-4180.

Development—Non Ferrous, PhD. or equivalent. Two years or more research development experience in physical metallurgy of copper and aluminum base alloys. For a research laboratory. $7000 to 10,000. East. S-4170.

Research—Non Ferrous Surfaces, a) PhD. Physics or electrochemistry. Familiar with fused salt chemistry, good experimentalist with interest in mechanism of fused salt-metal oxide reactions. b) PhD. or equivalent in physical surface chemistry, to deal with problems associated with surface reactions and oxide films. c) PhD. or Project Engineer in chemical metallurgy or surface physics. Will be responsible for major research projects. $7000 to 10,000 or more. East. S-4168.

Production Development, BS or MS in Met. or Weld. with 2 years experience in fabrication of ferrous and non ferrous light metals. a) Special experience in joining problems (welding, brazing, soldering). b) Special experience in magnesium castings metallurgy. Will work in a metallurgical and metal finishing group. Salary commensurate with experience. Los Angeles area. S-4160.

Laboratory Research, Met. E. with background in metallography, for studies in properties of hard metals in a new laboratory. Permanent and excellent opportunity. $600 to $750. San Francisco area. S-4142

Quality Control, BS Physical Metallurgy with some practical experience in stainless steel production welding. To set up standards and procedures for welding to client specifications, and responsible for shop inspection; able to work with shop. $550 plus. San Francisco area. S-4137

Production Scheduler, ME or IE, with 1 or 2 years working experience in planning, scheduling, production control and layout. Will assist industrial engineering department in maintaining production schedules and adjust to changing order requirements. For a high speed, high production manufacturing plant. $500 or so. Santa Clara, Calif. S-4131

Laboratory Metallurgist, Met.E. or ChE. with a couple of years laboratory work in control and testing work—preferably in industrial work including x-ray defraction and spectography, but not essential. To investigate metal alloys, steel products, chemicals in a private laboratory for quality control purposes. $500 or so. San Francisco. S-4081

PERSONALS

Peter P. Alexander, chairman of the board, Metal Hydrides Inc., recently received an honorary degree of doctor of science from Northwestern University, Boston, Mass., at the university's annual commencement exercises.

Hugh J. Murphy, formerly a student at the Massachusetts Institute of Technology, is now serving as Lieutenant with the United States Marine Corps.

Walter Bonsack, formerly a consultant in North Hollywood, Calif., is now serving as chief metallurgist to Aluminum and Magnesium Inc., and is concerned with the development of new alloys and their uses.

Donald Jaffe is now associated with the Bettis plant, Westinghouse Electric Co., Pittsburgh. He previously was employed by General Electric Corp., in the instrument Dept.

The alloy tube div. of the Carpenter Steel Co., Union, N. J., recently promoted **Nicholas Chernik** to assistant metallurgist.

S. T. Jawinski, director of research, Phoenix Iron and Steel Co., subsidiary of Barium Steel Corp., Harrisburg, Pa., recently received a doctor of science degree in metallurgy from Krakow Academy of Mining and Metallurgy.

Earl R. Parker, professor, University of California, recently accepted an appointment as a consultant to the metallurgy dept. of the scientific laboratory, Ford Motor Co., Dearborn, Mich.

George T. Murray, previously with the solid state sciences div. of Oak Ridge National Laboratory, is now a section manager with Materials Research Corp., Yonkers, N. Y. Murray recently received the D.Eng.Sc. degree from Columbia University.

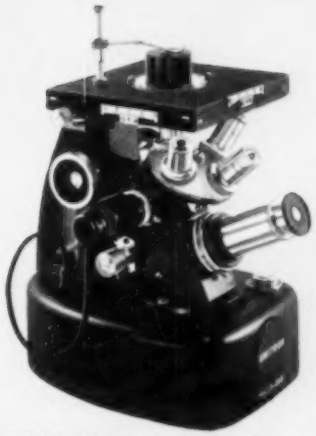
Oscar O. Miller of the International Nickel Co. Inc., was recently elected president of the Technical Societies Council of New Jersey Inc.

James G. Morrow, metallurgical engineer, Steel Co. of Canada Ltd., was recently presented with a certificate of his election to honorary membership in the American Soc. for Testing Materials.

(Continued on page 410)

These typical 25 took a total of 152

HERE ARE 25 DISCRIMINATING BUYERS WHOSE OVER 152 ORDERS AND REORDERS PROVE COMPLETE SATISFACTION WITH THESE TWO UNITRON INSTRUMENTS. AMERICAN BRASS, BATTELLE MEMORIAL INSTITUTE, CARNEGIE INSTITUTE, DOW CHEMICAL, E. I. DUPONT, GENERAL ELECTRIC, GENERAL MOTORS, GOODYEAR ATOMIC, I. B. M., MINNEAPOLIS HONEYWELL, M. I. T., MISSOURI SCHOOL OF MINES, MOTOROLA, NATIONAL BUREAU OF STANDARDS, NATIONAL CASH REGISTER, R.C.A., REYNOLDS METALS, UNION CARBIDE & CARBON, UNIV. OF COLORADO, UNIV. OF CINCINNATI, UNIV. OF WASHINGTON, UNIV. OF WISCONSIN, U.S. GOVERNMENT, U.S. STEEL, WESTINGHOUSE ELECTRIC.



MODEL MEC

UNITRON INVERTED Metallurgical Microscope: This compact unit provides many of the features usually found only in larger metallographs. Standard equipment includes optics for 25–1500X, polarizers, filters, transformer in base, etc. A built-in camera attachment for 35mm. photography is included with the binocular and available for the monocular model. Extra accessories include Polaroid camera attachment, vacuum heating stage and illuminator for transmitted light. Think of the time which your laboratory can save by providing each metallurgist with one of these handy, inexpensive units for use at his desk.

Monocular Model MEC $399 Binocular Model BMEC $615

MODEL U-11

UNITRON METALLOGRAPH and Universal Camera Microscope: A completely self-contained instrument of modern design for visual observation, photography, projection, and measurement of both opaque and transparent specimens; using bright field, dark field, or polarized illumination. Standard equipment includes all optics for 25–2000X, polarizers, filters, 3¼" x 4¼" camera, and many accessories. Also available are camera attachments for Polaroid, 35mm., and motion picture photography; vacuum heating stage for temperatures to 1500° C.; and macro-objectives (5–40X). Even laboratories on a limited budget can enjoy the precision, speed and efficiency possible only with a complete installation of this type.

Monocular Model U-11 $1195 Binocular Model BU-11 $1379

There is a free 10 day trial offer on any UNITRON Microscope.

Let the instrument prove it s value to you — in your own laboratory — before you decide to purchase.

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TRANSACTIONS

OF THE METALLURGICAL SOCIETY OF AIME

JUNE, 1959 ISSUE

The 1959 Institute of Metals Division Lecture
The Effects of Irradiation Upon Metals
by Frederick Seitz

The 1959 Howe Memorial Lecture
The Nonmetallic Constituents of Steel
by Clarence E. Sims

—COMPLETE CONTENTS—

The Effects of Irradiation upon Metals Frederick Seitz 354
The Nonmetallic Constituents of Steel Clarence E. Sims 367
Activity of Cd in Mg-Cd Alloys Richard J. Borg and C. Ernest Birchenall 393
Heat Content and Specific Heat of WC-Co Alloys H. J. Booss 395
The Effect of Torsional Strains on Self-Diffusion in Silver Single Crystals C. H. Lee and R. Maddin 397
Preparation of Anhydrous Chlorides of Cerium and Thorium R. Didchenko 401
Thermodynamic Treatment of Disproportionation Equilibria Involving Complex Ion Formation in Molten Salts K. Grjotheim and J. M. Toguri 403
Description of the Sigma Phase as a Structure with Sphere Packing H. P. Stüwe 408
Intercrystalline Fracture in Creep of Chromium and Some Chromium Alloys G. R. Wilms 411
The Third Stage of Work Hardening in Aluminum Crystals Deformed at 196°K S. Sato and A. Kelly 413
Role of Oxide Plasticity in the Oxidation Mechanism of Pure Copper J. A. Sartell, R. J. Stokes, S. H. Bendel, T. L. Johnston, and C. H. Li 420
The Preparation of High-Purity Uranium Metal by the Bomb Reduction of Uranium Tetrafluoride with Calcium R. W. Kewish, R. J. Bard, J. P. Bertino, O. E. Fry, S. W. Hayter, F. J. Hill, B. L. Kelchner, and A. W. Savage, Jr. 425
The Constitution of Aluminum-Rich Alloys of the Aluminum-Chromium-Manganese System J. W. H. Clare 429
Recovery of Decarburized Mild Steel H. L. Couch and J. D. Lubahn 433
Effect of Surface Condition on the Initiation of Plastic Flow in Mangnesium Oxide R. J. Stokes, T. L. Johnston, and C. H. Li 437
Solubility of Thorium Dihydride in Thorium Metal D. T. Peterson and D. G. Westlake 444
The Origin of the Preferred Orientation in the Columnar Zone of Ingots D. Walton and B. Chalmers 447
The Separation of Rare Earths by Ion Exchange J. E. Powell and F. H. Spedding 457
A Study of the Mode of Omega Precipitation from a Ti-13 Mo Crystal by Use of an X-ray Precession Camera S. A. Spachner and W. Rostoker 463
Tertiary Recrystallization in Silicon Iron J. L. Walter and C. G. Dunn 465
A Method for Growing Bicrystals of Copper J. Intrater and E. S. Machlin 471
High-Purity Tantalum R. F. Rolsten 472
Aluminum Grain Boundary Attack by Liquid Gallium C. Elbaum 476
Iodide Columbium R. F. Rolsten 478
The Observation of Dislocations and Other Imperfections by X-Ray Extinction Contrast J. B. Newkirk 483
Studies of Slugs from Explosives with Lined Cavities: II R. C. Deshpande and Sampooran Singh 497
The Isothermal Transfer from Solid to Liquid in Metal Systems J. M. Lommel and B. Chalmers 499
Twin Accommodation in Au Cd β' Alloys Howard K. Birnbaum 508
Fatigue in Single Crystals of Copper M. L. Ebner and W. A. Backofen 510
Solid-Solution Strengthening of Magnesium Single Crystals at Room Temperature E. D. Levine, W. F. Sheely, and R. R. Nash 521
Transmission Quantitative Metallography John W. Cahn and Jack Nutting 526
Anomalous Kinetics of the Bainitic Transformation Just Above the Martensitic Range M. F. Smith, G. R. Speich, and Morris Cohen 528
Quantitative Deformation Textures of Aluminum, Copper, Silver, and Iron Wires August Freda and B. D. Cullity 530
A Redetermination of the Lead-Lead Sulfide Equilibrium between 585° and 920°C J. R. Stubbles and C. E. Birchenall 535
The Crystallographic Angles of Indium E. A. Cisney 538
Effect of Prestrain on the Creep-Rupture Properties of High-Purity Aluminum and on Al-2 Pct Mg Alloy N. J. Grant, A. R. Chaudhuri, I. R. Silver, and D. C Ganow 540

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new books

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A Dictionary of Metallurgy, by A. D. Merriman, *Macdonald and Evans,* London, 425 pp., $18, 1958—This volume contains nearly seven thousand definitions including the more recently evolved words. In addition, there are 283 selected figures and 236 tables. The dictionary is bound in buckram.

Non-Destructive Testing, by J. F. Hinsley, *Macdonald and Evans,* London, 415 pp., $10, 1958—Consideration of the various aspects of safety and economy involved in testing materials and is aided by 400 illustrations. Chapters include such topics as Flaws and Defects: Their Origin and Detection, The Problem of Exploring "Solid" Bodies; Gamma Rays; and Safety & Precautions (Radiological). •

Reactors of the World, *Simmons-Boardman Publishing Co.,* 30 Church St., New York 7, N. Y., 12 folded plates, $2.50, 1958—Contains cutaway drawings with data on operating conditions for twelve nuclear reactors located in Canada, Great Britain, Russia and the U. S. These drawings were originally published in issues of *Nuclear Engineering,* London. •

Sheet Materials for High Temperature Service, *American Society for Metals,* 7301 Euclid Ave., Cleveland, 74 pp., $2.95, 1958—Discusses aspects of the properties and applications of precipitation hardening stainless steel sheet for airframes. Comprised of papers from the Southwestern Metal Congress in 1958, topics include high alloys of chromium, cobalt, columbium, molybdenum, and vanadium; ceramic coatings, electrical strain measurements, cold-roll forming process, joining and inspection of joints. •

The Solid State for Engineers, by Maurice J. Sinnott, *John Wiley & Sons Inc.,* 440 Fourth Ave., New York, N. Y., 522 pp., $12.50, 1958—Intended to acquaint engineers with the basic principles underlying the behavior of solid materials. Included are chapters which discuss crystallography, thermodynamic stability of solid structures and rates of change between states, types of solids: metallic, ionic, covalent, and molecular, as well as discussions of the mechanical and optical properties of solids. •

Successful Process Plant Practices, by Robert L. Davidson, *McGraw-Hill Book Co.,* 330 W. 42nd St., New York, N. Y., 302 pp., $10.00, 1958—Practical methods and devices to solve different problems relating to managing, scheduling, operating, maintaining, and repairing in the process industries, are the focal points for this book. Additional chapters include discussions of operating conditions, materials of construction, and the tools to be used. •

Techniques of Pressworking Sheet Metal, by Donald F. Eary and Edward A. Reed, *Prentice-Hall Inc.,* 472 pp., $12.00, 1958—Stress is placed on metal flow and movement which is used to analyze the forces involved in cutting, forming, and drawing sheet metal. •

Tooling For Metal Powder Parts, by George H. DeGroat, *McGraw-Hill Book Co.,* 330 W. 42nd St., New York, N. Y., 242 pp., $7.50, 1958—Among the factors discussed are designing parts, methods of production and preparation of powders, briquetting techniques, design of briquetting tools, and the various finishing operations. Prepared under the direction of *The American Society of Tool Engineers.* •

Unit Processes in Organic Synthesis, edited by P. H. Groggins, *McGraw-Hill Co. Inc.,* 330 W. 42nd St., New York, N. Y., 1070 pp., $17.50, 1958—Describes the fundamental scientific and technological principles used in converting organic raw materials into usable products by various processes. Among the processes discussed: nitration, animation by reduction, ammonolysis, oxidation, hydrogenation, hydrocarbon synthesis and hydroformylation and polymerization. •

Vacuum Metallurgy, edited by Rointan F. Bunshah, *Rheinhold Publishing Co.,* 430 Park Ave., New York, N. Y., 472 pp., $12.50, 1958—Encompasses many aspects of vacuum metallurgy, vacuum melting techniques, (including the electron bombardment) and the degassing of metals, and the metallurgical applications of vacuum processing to powdered and electronic materials, coatings, and high-temperature alloys. •

Vacuum-Tube and Semiconductor Electronics, by Jacob Millman, *McGraw-Hill Book Co. Inc.,* 330 W. 42nd St., New York, N.Y., 644 pp., $10.00, 1958—Author Millman presents an integrated treatment of vacuum tubes and transistors. Beginning with the motion of charged particles in a vacuum, and the electronic theory of a metal, the book continues with the nature of semiconductors, analysis of the vacuum diode, the p-n junction, vacuum triode characteristics and their equivalent circuits, and other transistor and equivalent circuit characteristics. •

education

SUMMER SESSIONS

► **New York University's College of Engineering** announces two one-week programs on its Summer calendar.

On June 15th to 19th, thermoelectric materials and devices will be the topic of discussion at a 21-lecture series on the University Heights campus in the Bronx.

The series is "designed to acquaint engineers and scientists with the current theory and state of art of materials and devices based on the thermoelectric effects," according to Dr. Irving A. Cadoff, the program's chairman.

"The sequence of lectures will be such that the fundamentals of materials selection and device design are covered first," says the associate prof. of engineering." This will enable engineers and scientists with no previous experience in thermoelectricity to profit fully from subsequent lectures."

Then, on June 29th to July 3rd, the University Heights campus will present a ductile iron summer program. Designed for engineers and others engaged in or interested in ductile iron technology, the program consists of 25 lectures.

The keynote address will be delivered by D. J. Reese, director of the Ductile Iron div., International Nickel Co.

A partial listing of topics includes: Iron-Carbon Diagram and Steels, Cast Irons and Malleable Irons, Theoretical Considerations of Spheroidal Graphite Formation, Machinability and Welding Characteristics, and Properties and Applications of Ductile Ni-Resist.

Sand molding practices in ductile iron, shell molding of ductile iron, and ductile iron's applications in gear and power machinery are other topics to be discussed.

Co-sponsors of the program are the Department of Metallurgical Engineering, and the University's Office of Special Services to Business and Industry.

Registration fee for each of the courses is $110; $35 for one day. Additional information on both summer sessions may be obtained by contacting: *Mr. M. Berk, Dept. of Metallurgical Engineering, New York University, College of Engineering, University Heights, New York 53, N. Y.*

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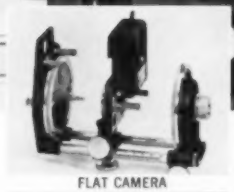

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THE NEW HAYDEN SMELTER

Its Unique Design Features

Construction of a copper smelter is something which does not take place every day on the American scene. The Hayden smelter of Kennecott Copper Corp., which went into operation only a few months ago, incorporates the most advanced ideas of copper smelting. These are described by a senior engineer of the firm which constructed this smelter . . . the Western-Knapp Engineering Co.

An Introduction

Arizona is a colorful state of vast mineral resources. And it is there, along the banks of the Gila River that we find the town of Hayden. Long the site of Kennecott's flotation mill and ASARCO's smelter, it has now become a two smelter town—probably one of the few in existence— with the erection of Kennecott's $25 million smelter.

The smelter's ultra-modern design features are described on the following pages in an article by one of the engineers on the construction project. There are, however, a few comments on the smelter which your managing editor would like to make after having toured the plant.

First of all, the plant is impressive; it is scrupulously clean and well laid out. The construction of the plant itself—the massive beams used in it and the generosity of space given to each department—shows that funds were not spared to make this plant a showplace of the copper industry. And parenthetically, it should be added, that it is to be hoped that construction work on any future copper smelter is started in times of high copper prices.

Another thing is immediately apparent: there aren't many workmen to be seen in this plant. It was reported that 131 men were being used on the three-shift operation, although the smelter contemplates hiring several additional persons. This is in marked contrast to the 170-man force at Kennecott's Chino smelter, which is of comparable size. The difference in operating costs is apparent.

Several features of the reverb furnace are particularly notewothy. The charging system permits easy handling of the concentrates and their efficient introduction into the furnace. This is described in some detail in the following article. The preheater for the air for the furnace burners results in higher operating temperatures in the furnace—from 2700° to 2900°F—and hence an increase of some 40 pct in the furnace output.

At present the reverberatory furnace is charged with wet concentrates averaging about 10 pct moisture. However, recent use of drier concentrates from storage piles has shown the advantage of using dry concentrates. It is estimated that reverb furnace output may be increased by as much as 8 pct by such a changeover. Serious consideration is apparently being given to the installation of a concentrate drier.

From these observations, it is evident that operating costs of the new Hayden smelter must be as low as any in the US, in spite of the low-grade—15½ pct Cu—concentrate which comprises its feed. The plant is a monument to the copper industry.

F. Weston Starratt

Hayden, Arizona . . . with Kennecott's new copper smelter in the foreground and its sponge-iron plant for the LPF operation immediately behind. Two stacks in the background belong to ASARCO's copper smelter. Kennecott's flotation mills are at the right.

by Ralph K. Johnson

In the design of the new Hayden smelter at Hayden, Ariz., a good deal of research was conducted into the design and characteristics of existing smelters in an effort to determine where new ideas and improvements might be forthcoming. Using this as a starting point, engineers from Kennecott Copper Corp. and Western-Knapp Engineering Co. went ahead to lay out the design of the new Hayden smelter, which is felt to be the most modern, and likely the finest, in the industry.

The smelter was designed to treat a nominal 812 dry tons per day of copper concentrates transported from Kennecott's mill facilities at Hayden, with reserve capacity for smelting up to 1000 dry tons per day. The production of copper was to approximate 240 tpd in the form of 700-lb Baltimore-type copper anodes.

The smelter was designed around one central building which is the focal point of the smelter; it houses not only one reverberatory furnace, a power-house annex, three converters, two anode furnaces, and one anode casting wheel, but also a repair shop, brick storage area, reverb air-preheater installation, and the various offices, lunch rooms, and storage areas for the reverb and converter departments. In addition, the design of the smelter building was to be such that, at some future date, a second reverberatory furnace and two additional converters could be installed without interrupting smelter operations and without the need for additions or alterations to the building structure.

Special areas are provided for the future construction of a sulfuric acid plant and for the possible installation of a concentrate drying plant and/or a roasting plant. In addition to the filter plant, the design of the smelter site includes an outside storage area with handling facilities for emergency storage of concentrates from the filter plant, a flux-crushing plant with outside storage bins and reclaiming equipment, and a concentrate storage building with provisions for storing, mixing, fluxing, and reclaiming concentrates.

The major units of the Hayden smelter began operation on June 24, 1958 with the first anodes being cast on June 29, 1958. Typical results of a recent month's operation are given in Table I.

The features of the main smelter departments are discussed in the material which follows:

RALPH K. JOHNSON is with Western-Knapp Engineering Co., San Francisco, Calif.

Concentrate pumping station

The concentrate pumping station receives the sulfide and LPF (Leach-Precipitation-Flotation) concentrates as slurries from the nearby Kennecott mill. These slurries, after sampling, are combined and sampled again and then stored in two 20-ft diam agitator holding tanks. From the holding tanks, the slurry is pumped approximately 2900 ft through a 6-in. pipeline to the filter plant. Two sets of two, rubber-lined slurry pumps are used to pump the slurry, which runs 27 pct solids by wt, 100 pct −65 mesh, and 1.27 sp gr. One set of slurry pumps is normally on standby status. The speed of the pumps, connected hydraulically in series, can be adjusted for a flow rate of 400 gpm (812 tons of concentrate per day) or 490 gpm (1000 tons of concentrate per day).

Filter plant

The filter plant, located at the new smelter, receives the slurry from the concentrate pumping station and functions to separate the water from the concentrate by using hydraulic cyclones and dual-vacuum disc filters.

The slurry is pumped by rubber-lined pumps to a tapered cyclone manifold. Three cyclones feed from the manifold at 20 psig inlet pressure. Normally, two cyclones are in operation with the third on standby. Cyclone underflow of approximately 74 gpm at 70 pct solids combines with the underflow from the thickener, 50 gpm at 60 pct solids, to form the feed for the vacuum filters. Cyclone overflow of approximately 416 gpm at 11.8 pct solids is laundered to a thickener. The thickener is 80 ft in diam by 12 ft deep and is located outside and adjacent to the filter plant.

Three separate filtering circuits are employed to receive the underflow from the cyclones and thickener. Normally, two are in operation with the third on standby. Each filter is a 6-ft diam, 8-disc machine with 400 sq ft of filter area. The design rate of the filters is 105 lb of filter cake per sq ft per hr, and all filters discharge to a common collector belt running below. Moisture content of the filter cake approximates 10 pct. Filtrate from the filters is returned to the thickener for final clarification and thickener overflow is returned to the mill through the return line in the pipe tunnel.

Of particular interest in the filter plant is the system for automatic operation. The filter plant was designed to be operated with or without an operator in attendance. For unattended operation, controls are arranged to provide automatic shut-down of the plant in the event of equipment failure.

From the filter plant, the concentrate is weighed and conveyed either to the concentrate storage building or to the outside storage area.

Table I. Operating Results in a Recent Month at Kennecott's Hayden Smelter

Concentrate smelted, tons	27,794
Copper precipitate smelted, tons	1,075
Converter flux smelted, tons	6,003
Copper anodes produced, tons	5,745
Gross Btu per ton NMBM (furnace)	6.5 million

	Cu, Pct	Fe, Pct	S, Pct	SiO_2, Pct	Al_2O_3, Pct	CaO, Pct
Copper concentrate	15.4	31.0	36.0	11.0	4.3	Nil
Reverberatory slag	0.34	36.1	1.3	37.6	9.6	3.5
Converter slag	2.35	49.1		25.2	5.4	0.1
Matte	27.2	40.7		0.8	1.3	Nil

Concentrate storage building

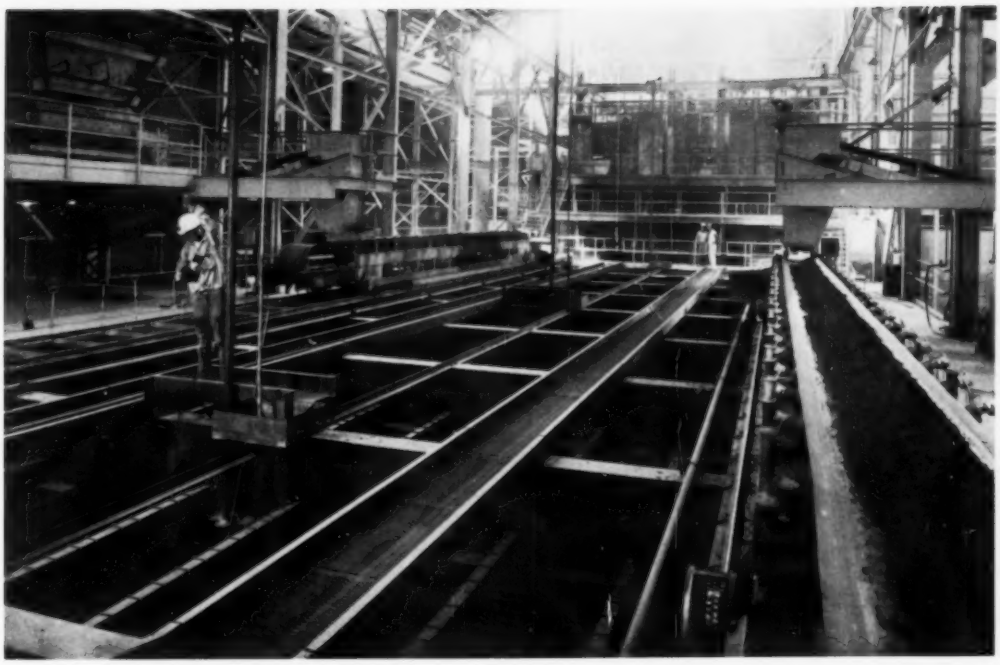
The concentrate storage building provides storage and removal facilities for the concentrate received from the filter plant, and the copper precipitates recieved by gondola car from Kennecott's precipitating plant at its Ray mines. Removal from storage is accomplished with two 10-ton capacity, overhead, traveling grab-bucket cranes. Of special interest in the crane installation is the system employed in handling the concentrate. Each crane is equipped with a 14-cu-yd capacity hopper, which is suspended below one end of the crane and rigidly fastened to the crane bridge. The hopper, in turn, is equipped with a 48-in. belt-feeder, controlled by the crane operator, which feeds from the hopper to a 24-in. gathering belt conveyor located near the wall of the building. With a minimum of crane movement, therefore, the crane operator is able to charge the hopper and thereby reclaim concentrates, as needed, from storage.

Lime rock flux, from a 350-ton capacity outside storage bin, is added in predetermined amounts to the concentrate on the gathering conveyor. Concentrate from outside storage, transported by front-end loaders and belt conveyor, is also discharged to the gathering conveyor where fluxing is accomplished. From the concentrate storage building, the concentrate is handled by a system of belt conveyors which terminates at two 490-ton capacity storage bins located over the reverberatory furnace.

Flux crushing plant

The flux crushing plant is utilized to crush and deliver to outside storage, silica rock, lime rock, and smelter reverts. Mine-run silica rock, received in gondola cars from the pit at Ray, is dumped through a 24-in. grizzly into a 250-ton capacity track hopper. From the hopper, the silica rock is fed by a 60-in. wide by 20 ft long Mn-steel apron-feeder to a 30x42-in. jaw crusher for primary crushing. The crusher discharge is then fed by belt conveyors to a 4x8 ft single-deck screen. The oversize material from the screen is further reduced by crushing in a 10x51-in. hydro-cone crusher. The undersize material from the screen is combined with the cone-crusher discharge and is conveyed to outside storage by a tripper conveyor. All material transfer points in the crushing plant are covered and connected by ductwork to a wet-type dust collector located outside the building.

Lime rock and smelter reverts are delivered to the crushing plant by truck and are dumped through a special truck-sized door into the track hopper. Crushing of lime rock is similiar to silica rock except for a finer setting of the cone crusher. Lime rock is normally crushed about once a week. Separate outside storage bunkers are provided for the crushed fluxing materials to insure that mixing does not occur. An interesting innovation in the design of the flux crushing plant is the system of



electrical interlocks. The resulting dangers of accidentally mixing lime rock with the silica rock used for converter fluxing were given careful consideration in the design of the flux crushing plant. An interlock system was designed which would require the outside storage tripper to be located over the lime rock storage pile before lime trucks could dump into the track hopper, and before the crushing plant could be started. Interlocks were also provided on all belt conveyors to prevent material spillage and belt damage, in case of breakdown. All conveyors are equipped with an emergency trip-wire, which will stop the conveyor and thereby actuate the interlock system.

Lime rock is reclaimed from the storage pile by front-end loaders, which transport it to the lime storage bin adjacent to the concentrate storage building. Silica rock is reclaimed through drawdown gates in a reclaim tunnel beneath the storage pile, and is transported by a system of belt conveyors either to the storage bin for the reverberatory furnace or the storage bins behind the converters.

Above, mechanized belt-charging system on the reverberatory furnace with waste-heat boiler in background. Below, converter aisle with anode furnaces in background. Ladle at right is pouring converter slag into the reverb.

Reverberatory department

Green smelting of the concentrate is accomplished in a 35 ft wide by 120 ft long (outside dimensions) all-basic-refractory reverberatory furnace with a Detrick-type suspended arch. The concentrate is transported from two 490-ton capacity storage bins, located above and to the sides of the furnace, by a feeder-belt system which ultimately feeds two, traversing-type, self-propelled belt feeders or *shuttle belts*. The shuttle-belts are located on top, and to the side of, the reverberatory arch, and traverse the length of the furnace. Control of the conveyors is from push-button panels mounted directly on the conveyor frame. The panels are readily accessible to the operator. Besides traversing back and forth, the belt of each shuttle-conveyor is

reversible, thereby enabling the conveyors to charge concentrate directly over the head pulley, or tail pulley, to any of the 64 (32 per side) furnace charge hoppers located immediately below.

Although this particular installation is not the first of its kind, it is felt to be a refinement in the general design which uses a system of conveyor belts to feed the furnace. The entire top of the furnace, including the boiler up-take, is also free from obstructions. This feature permits easy fettling and arch maintenance, using one 5-ton capacity, overhead crane.

The reverberatory furnace charge hoppers are arranged in a row above and along each side of the furnace. They are nominally 3 ft sq at the top, are closely spaced, and taper to approximately 9 in. sq at the arch line. The concentrate is admitted to the furnace by means of a slide-gate assembly, which is bolted to the hopper. The slide-gate is controlled by a lever arrangement, which is actuated by the operator charging the furnace. This particular slide-gate is an improved version of an earlier design used in the industry, and was designed to be self-cleaning and *plug up* proof. No operational difficulties have occurred.

The reverberatory furnace is constructed on a massive and heavily reinforced, concrete foundation which extends some 12 ft 4 in. above the surrounding grade. The foundation encloses the furnace bottom, consisting of compacted clay, crushed magnetite, and fused slag, and it supports the side and end walls of the furnace. Side wall thickness ranges from 4 ft below bath level to 1½ ft above. The cross-section of the furnace is constant throughout the entire length, and arch thickness is a nominal 15 in.

Of special mention in the design of the furnace is an air-cooled, up-take pilaster, and a *dutch-oven* extension to the burner end of the furnace. The up-take pilaster brickwork has internal slots through which 15,000 cfm of air is blown for refractory cooling purposes. The *dutch-oven* extends some 8 ft out from the furnace bridge-wall and is approximately 27 ft long. Eight, multiple-jet-type, combination oil and natural gas burners are supported at the end of the *dutch-oven*. The single converter slag return launder enters the roof of the furnace at the center line and just inside the bridge wall. The *dutch-oven* offers the advantage of higher smelting zone temperatures in the furnace and better combustion and heat release of the fuel.

The air for combustion (50,000 cfm at 60°F) is heated to approximately 700°F by a counter-current, regenerative-type air preheater installation, which is complete with a direct-fired natural gas furnace. Control of the preheater and furnace is completely automatic except for manual light-off of the furnace burners. Controls also include *fail-safe* interlocks, which will automatically shut down the preheater installation in case of equipment failure or abnormal operation.

Slag can be tapped from both sides of the reverberatory furnace, near the up-take end: it is transported by launders to 225-cu-ft slag cars. Matte is tapped from either side of the furnace, near the burner end, and is transported in 200-cu-ft ladles by self propelled transfer cars to the converter aisle. Separate fume control systems are provided at each furnace tapping location to exhaust all fumes to atmosphere.

Another interesting innovation in connection with the reverberatory furnace installation is the provision of a vacuum cleaning system for cleaning the general furnace area. All reclaimed dust from the vacuum cleaning system is returned to the smelting process.

The reverberatory installation includes two, waste-heat-type, steam generating boilers. Each boiler is rated at 66,000 lb of steam per hr at 450 psig pressure and 750°F.

Converter department

From the converter aisle, the 200-cu-ft matte ladles are hoisted from the transfer cars by one of the two, 60-ton capacity, overhead traveling, converter-aisle cranes. The cranes, each equipped with two, 20-ton auxiliary hoists and a completely enclosed and air-conditioned operator's cab, transport and charge the matte into one of three, 13 ft diam by 30 ft long Pierce-Smith-type copper converters. Two of the converters are operated normally with the third on stand-by. The converters are lined with 18 in., burned chrome-magnesite refractories and are equipped with 64, automatic pneumatic-type tuyere punchers. Converter air, 25,000 cfm at 15 psig pressure, and puncher air at 100 psig pressure are delivered to the converters from the powerhouse. The converters are driven at 0.6 rpm by a 75-hp motor, and the drive arrangement of each includes an air-operated emergency turn-out mechanism. The converter department is also equipped with a vacuum cleaning system, which is similar to the one installed in the reverberatory department.

Each converter is controlled locally from an operator's console located at the converter. The air for the converters can be controlled from this console or remotely from the powerhouse. The tuyere punchers can be set by an adjustable timing mechanism to operate automatically or can be operated manually.

Each converter is equipped with a spark-shield, which not only affords the necessary protection from falling sparks, but also provides ventilation for the puncher operator. A 1600-cfm axivane fan operates continuously to blow air into a long, dead-end tube, which is a part of the shield; the tube, in turn, directs the air through holes to the operating area. In addition, when the converter is out of the stack and the shield has covered the tuyeres, the long tube is in a position to direct the cooling air directly on the punchers and actuating mechanisms. This feature helps to keep the puncher mechanisms from overheating when the converter is out of the stack. The spark-shield is hinged to the converter apron-plate, and through a system of cam-tracks and counterweights, moves, by virtue of the converter rotation to wrap into the curvature of the apron-plate whenever the converter is rolled out of the stack. Conversely when the converter rolls back into the stack, the spark-shield opens to allow access to the punchers.

Another interesting modification in the converter installation is the system employed for hoisting the converter rolling-door and the converter flue-damper. The design of the hoisting system used at the Hayden Smelter was patterned after the freight-elevator principle. Nearly all of the direct loads are balanced by counter-weights. The remaining load is handled very easily by a relatively small, electric hoist of standard design.

The converter hoods, lined with cast-iron liners, are each equipped with an opening through which the silica-flux is added. Silica is transported from storage bins located behind the converters by a system of belt conveyors which terminates at the converter hood. The conveyor at the hood-end of the system discharges silica directly into a chute feeding the converter. Because of the heat problem this conveyor is driven at the tail-pulley.

Anode casting department

The blister copper received from the converters is charged into the anode or *poling* furnaces. Each of the two, 13 ft diam by 30 ft long furnaces is identical with the basic converter design previously discussed with the exception of the tuyeres, air-piping, spark-shield, apron, spout, and charging-hole configurations. The 250-ton capacity furnaces are grouped around one common anode casting-wheel. Poling of the furnaces, to rid the blister-copper of excess oxygen and other wastes left over from the converter operation, is accomplished by inserting oak-poles into the furnace bath using a special system of electric and air-operated poling hoists. The control of the furnace, the casting-wheel, and the pouring spoon is accomplished from one of two control booths. These booths are completely enclosed and air conditioned; they are equipped with push-button type control panels. The casting wheel is a flat-deck type, 32½ ft in diam, with provisions for casting 22 700-lb Baltimore-type copper anodes. The wheel is driven by two 5-hp dc motors; casting is at a rate of approximately 42 tons per hr.

After the anodes are cast, they are removed from the casting-wheel by a bosh-crane and placed for further cooling in the two bosh-tanks filled with water. When the bosh-tanks become filled with anodes, the anodes are lifted out and transported to a storage area by a 15-ton capacity, overhead traveling crane. The anodes are then loaded into railroad cars and shipped to the refinery for additional processing.

Dust handling

The reverb and converter flues of the Hayden smelter are the familiar balloon-type; they are equipped with screw-conveyors to collect and transport the flue dust to a pug-mill. From the pug-mill, the flue dust is returned to the smelting process by belt conveyors. The flues are fabricated from all-welded ¼ in. plate with ½-in. bar stiffeners; they have accordion-type expansion joints on 21-ft centers and are suspended from an overhead support structure by 1-in. diam rods. In addition, the flues are insulated for maximum heat retention and have a roof structure over them in all outside areas.

An interesting modification in the method of collecting dust from the flues is utilized. Instead of discharging dust directly into the screw-conveyor, which has been a former practice, the flue discharges into an *off-set* outlet which, in turn, connects to the screw-conveyor housing. The connection of the off-set outlet with the conveyor is completely flexible; it not only allows for relative movement of the flue in the vertical direction, but for horizontal movements as well. All conveyors are supported separately so that no stresses, set up by the differential expanion of the flues, can be transmitted to the conveyor structure. In being off-set, the outlets also tend to eliminate the danger of large dust lumps, or flue liners, falling directly into and damaging the conveyor flights. Another advantage of the off-set design is the ease of conveyor maintenance. When it becomes necessary to replace a conveyor flight, no head-room problems will be encountered with the flue structure being in the way.

Power house

The powerhouse annex is located at the southeast corner of the main smelter building and houses the turbo-generator, converter-blowers, air-compressors, pumps, switchgear, and water treatment equipment. A 15-ton capacity, overhead-traveling crane is provided for servicing powerhouse equipment. Space has also been provided in the design of the powerhouse for a second turbo-generator and a fourth converter blower. Most of the powerhouse equipment is controlled and instrumented from a centrally located, air-conditioned control room.

Turbo-generator specifications are 9375 kva at 0.8 power factor, three phase, 60 cycle, and 6900 v; the generator driven at 3600 rpm by a 14-stage, straight-condensing, 9375-kw steam turbine. Throttle conditions of the steam are 400 psig pressure at 750°F.

Three converter blowers are provided. Each is a three-stage centrifugal type rated 25,000 cfm air at 18 psig outlet pressure, and each is equipped with inlet guide vanes. The blowers are driven at 5160 rpm by 1970-hp straight condensing steam turbines. An interesting innovation in the control system of the blowers is that any of the three converters can receive air from any blower by means of manifolding. Normally, however, one blower is used with one converter. In addition, the blower controls at any converter can be arranged to control any given blower which might be operating.

Gas handling

The reverberatory and converter flue gases are treated for final dust separation in a four-chamber, 60 gas duct, three-field-type, electrostatic precipitator. The capacity of the precipitator is 300,000 cfm at 10 pct moisture and 500°F. All dust rappers are of the pneumatic type, and the dust is collected and transported to the pug-mill by screw conveyors. The fields are energized by six, 30-kva, double-half-wave, selenium power units. From the precipitator, the gases are channeled by a brick by-pass flue to the 600-ft high, brick-lined, reinforced-concrete stack where they exhaust to atmosphere.

Conclusion

The design features herein presented of Kennecott Copper Corp.'s newly constructed copper smelter at Hayden, Ariz., include only a few of the more important innovations and modifications. Credit for the success of the smelter project is rightfully due to all of the engineers, designers, and personnel from the various smelters who were associated with, and contributed to, its design and construction.

The finished design of the Hayden smelter is felt to represent the latest in engineering thinking and reflects in its construction the *new ideas* and practical *know-how* of the entire copper smelting industry.

LEACH-

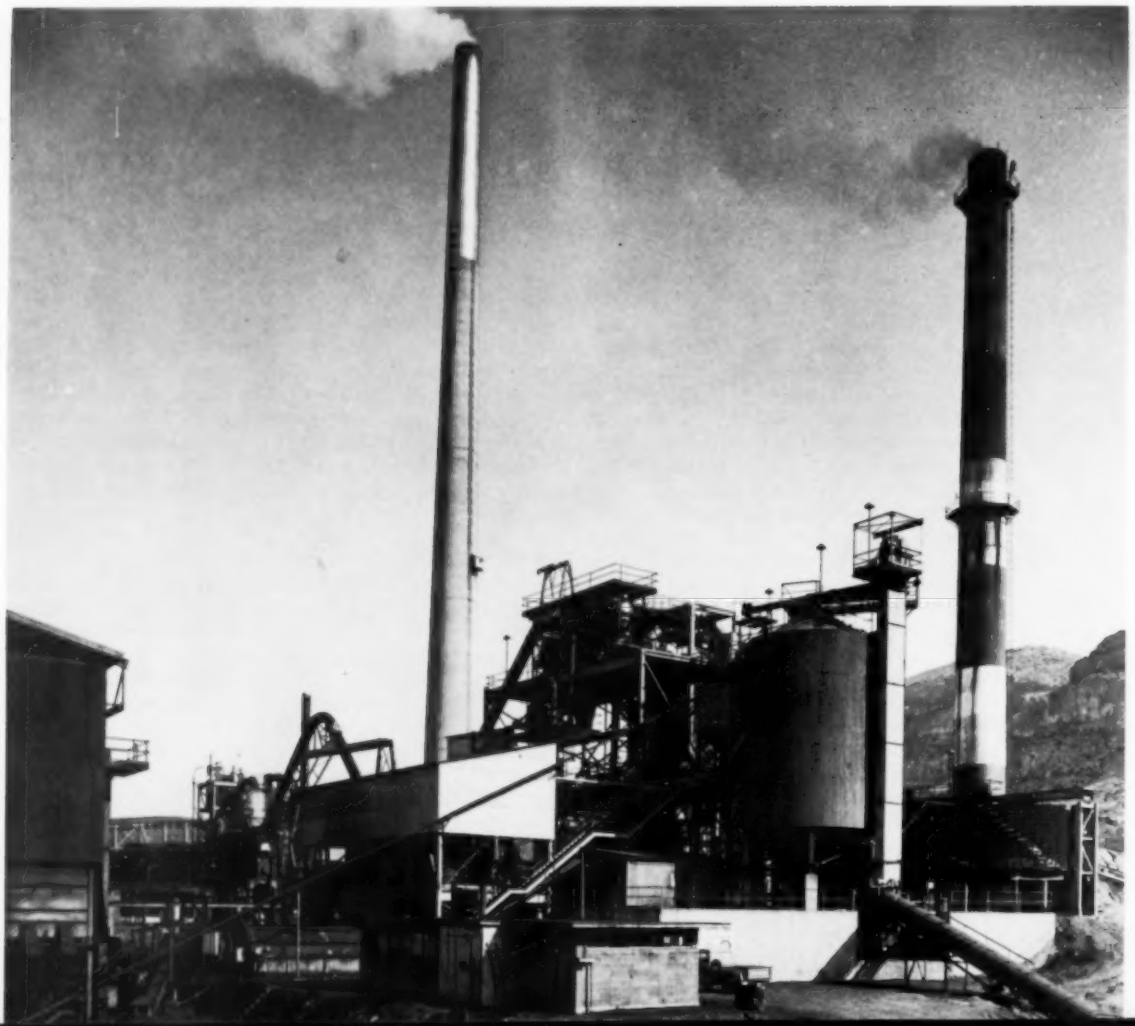
PRECIPITATION-

FLOTATION

PROCESS

To Ray Mines div. of Kennecott Copper Corp., LPF means the recovery of 2 lb of copper per ton of mill feed. Non-sulfide copper minerals are treated by leaching with sulfuric acid and precipitation by sponge iron produced from pyrite concentrate. This article outlines the process with particular emphasis on the sponge-iron plant, shown in the photo below.

by M. W. Franz



The Ray LPF process has been in operation for about two years. To a large degree, large-scale operations have confirmed the predictions of the small-scale investigations. Significant amounts of non-sulfide copper, heretofore lost, are being recovered, and what may have been a marginal mining operation is now a successful one. In fact, work is now underway to determine whether this process should be installed at other Kennecott properties having similar problems.

What are these problems, and why use LPF to solve them? The Ray mining operation is conducted so as to provide a maximum recovery of both copper and pyrite. The schist and prophyry are partially oxidized and contain copper in the form of chalcocite. The diabase contains both chalcopyrite and large quantities of pyrite. About 20 pct of the copper in the schist is in the form of non-sulfide minerals: carbonates, silicates, and sulfates. The LPF process has been designed to recover this copper, which amounts to about 2 lb of copper per ton of mill feed.

Both sponge iron and sulfuric acid for the LPF process are produced from Ray pyrite concentrates. It is this distinctive feature of the process which, in large measure, contributes to its economic success. The use of sponge iron as the precipitant for the leached copper permits a circulating load of sponge iron contacting the pulp at all times and, thus, prevents resolution of the copper in the acid circuit. Sponge iron also enables complete and rapid precipitation of copper in a flocculated form suitable for recovery by flotation techniques.

The following are the steps in the LPF process:

1) Separation by classification of the primary rod-mill discharge into a sand and a slime fraction;

2) Superficial leaching of the sands and combining this pregnant solution with the original slime fraction for final leaching;

3) Precipitation of the resulting dissolved non-sulfide copper of the leach solutions;

4) Recovery by flotation of the cement copper and of the finely divided sulfide copper which reported in the slime fraction;

5) Recovery of pyrite from the previously discarded sulfide tailings for the sponge iron and acid plant requirements;

6) Dead roasting of the pyrite in a fluid bed reactor to produce sulfur gases for acid production and iron calcines;

7) Reduction of the iron calcines to metallic iron sponge; and

8) Separation of the crude sponge from the unburned coal or coal char and grinding and screening the sponge for use in the LPF section of the concentrator.

The sponge-iron plant

Thickeners and feed system

From the pyrite section of the Hayden concentrator a pyrite concentrate of about 15 to 20 pct solids and about 40 pct Fe content is pumped to a 40 ft diam conventional thickener located at the sponge-iron plant. The clarified overflow is returned to the mill. The thickened underflow at about 65 to 75 pct solids is pumped to one of two 12-ft diam air- and rake-agitated feed tanks. When excess pyrite is produced at the mill, thickener underflow is diverted to storage bins or to earthern ponds. But when insufficient mill concentrates are produced, the dried, stockpiled pyrite must be repulped and used as reactor feed. This is accomplished by a modified pug mill and a small agitated holding tank, from which the slurry can be pumped either to the thickener or directly to one of the feed tanks.

Thickened slurry at about 70 pct solids is pumped out of the feed tank directly into the reactor. There are two feed nozzles or feed guns, one for each tank, but only one feed nozzle and feed tank is used at any one time. The other feed tank is either being filled with pyrite slurry or the valves on the feed gun are so positioned to recirculate the feed within the tank itself.

Fluid bed reactor

The fluid bed reactor is a totally enclosed brick-lined single compartment chamber of 22 ft inside diam with inside walls 14 ft high. Low pressure air supplied by a 300 hp blower is used for fluidization and for supporting the reaction of burning pyrite to iron calcines. The air is introduced into the reactor bed by means of tuyeres made of stainless steel castings having ⅛ in. diam holes drilled in the upper section. These are screwed into couplings which are welded to a horizontal reinforced steel constriction plate which separates the windbox from the reaction chamber. The tuyeres are spaced 10 in. center to center.

Exothermic heat from the oxidation of the pyrite is usually in excess of that required to maintain the reaction temperature. This excess heat is removed by vaporizing additional water, which is introduced into the reactor through the feed guns.

The iron oxides or hot calcines are removed from the reactor chamber by gravity through a bed overflow pipe, and the suspended solids and gases are taken off through the top of the reactor. The gas stream passes through the two banks of hot cyclones which remove most of the suspended solids. Cleaned gases go either to the contact acid plant or to the main stack to be discharged into the atmosphere. At the base of each cyclone and in the bed overflow pipe, there are special seals which permit the solids to pass, with the gases going as outlined above. Solids recovered from the cyclones are combined with the solids from the bed overflow and, together with coal, are introduced by gravity feed pipes into the Bruckner furnace for reduction of the oxides to metallic sponge iron.

Bruckner furnace

The Bruckner furnace is a modified rotary kiln having a deep bed or charge. The furnace is completely lined with high-heat-duty firebrick to an inside diam of 8 ft. Total length of the furnace is 30 ft. The entire unit rotates at 1 rpm on heavy cast-iron trunnion rollers. Reaction temperatures are maintained within the furnace through the use of natural gas burners, firing countercurrent to the feed. Retention time within the furnace is about 2 hr. The tendency for large-sized agglomerates to form has been reduced to the point where they are no longer troublesome. This has been accomplished by establishing precise and consistent optimum firing conditions, which are closely followed by the furnace operators.

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Baker cooler

The reduced iron sponge is discharged by gravity through the firing hood of the Bruckner furnace and drops through a water-cooled chute into the Baker cooler. This cooler is a gas-tight cylinder 7 ft in diam and about 40 ft long which rotates at 4 rpm on its long axis in a bath or tub through which water is circulated. At the feed end, the rotating cooler shell is in contact with a stationary seal made of a brake lining material. The inside of the feed end has a simple hinged flap valve which opens as the hot material enters. Cooled sponge iron is discharged through an automatic mechanical port and falls upon a system of conveyors which transport the crude sponge to the screening plant.

Screening plant

In the screening plant, the cooled sponge iron passes first through a grizzly with the oversize going through a jaw crusher, which discharges material at about ¾ in. size. There is a surge bin within the screening plant which can accommodate about 18 hr production. Crude sponge, either from current production or from the surge bin, goes over a vibrating screen having a 28-mesh deck. Undersize goes immediately to the product bins. Oversize goes to the dry magnetic separator which separates the unburned coal or coal char from the sponge iron. Oversize magnetic material is then conveyed to a 4x6 ft rod mill which is in closed circuit with the screen. Coal char is returned to the feed of the Bruckner furnace for reuse. The sponge iron product is transported to the mill by means of a specially constructed truck.

Acid plant

The contact acid plant is a conventional unit of 100 tons per day capacity. A combination of water impingement and spray tower, a mist Cottrell, and a drying tower serve as the gas cleaning units. In addition to absorption towers and heat exchangers, a converter tower contains vanadium pentoxide as the catalyst. The correct amount of oxygen input as well as temperature regulation of the converter is accomplished by chain operated valves. Two steel tanks provide storage capacity for approximately 1300 tons of acid. Sulfuric acid is transported from these storage tanks to the mill storage tanks by means of a pipeline.

The Concentrator

Fig. 1 is a representation of the present flow sheet of the entire LPF process. At the right hand side and extending from the top to bottom is shown the material flow within the sponge iron and acid plant which has just been reviewed. In looking at the mill a first glance would indicate that the milling is rather complicated. If we trace out what takes place, this soon becomes fairly simple.

Grinding, leaching, and classifying

Ray ore is partially crushed at the mine site and is shipped to the mill in railroad cars. There are the usual storage bins, feeders, etc. before the primary rod mill. Basically, the rod mill discharges a pulp at about −3 mesh. Sand-slime separation occurs early in the circuit, by means of 24 ft bowl classifiers and wet cyclones, and the initial sands are sent to the leaching drums. Approximately 95 pct of the −200 mesh material reports as slime. Sulfuric acid is added to the leaching drums together with secondary sands from the wet cyclones. Pulp in the leaching drums is kept at a pH of about 2.

Two rake-type washing classifiers in series separate and wash the leached oversize material from secondary slimes and acid soluble material. The leached, washed oversize material is then sent to the regular sulfide and pyrite section of the concentrator. The slimes, plus the initial pregnant solutions from the four parallel circuits are then combined and are again subjected to acid leaching in a single leach tank 40 ft in diam. More acid is added to this tank and the contents are maintained in a state of agitation by means of circulating pumps.

Precipitation, conditioning, and flotation

From the leaching tank, the pulp is again split equally and sent to four identical parallel circuits which make up the precipitation, conditioning, and flotation sections of the LPF process. Virgin sponge iron, plus reclaimed sponge iron from the magnetic separators, is contacted with the leaching tank pulp in the precipitating cells. The precipitating cells discharge into conditioning cells to which are added Minerec A and pine oil. The conditioning cells discharge into roughers with the rougher concentrate going into cleaner cells. The rougher tails go to scavenging conditioners and scavenger float cells. Minerec, pine oil, and more acid are added just ahead of these last conditioners in which a pH of about 4 is maintained. Scavenger concentrate is sent to the cleaner cells, and scavenger tails are pumped to the wet cyclone bank where a slime discard is made, with the cyclone spigot product going to a wet magnetic separator. The non-magnetic pulp goes to a single set of scalper cells, the concentrate of which is returned to the rougher conditioners along with the cleaner tails. Raconite, a crude butyl xanthate and pine oil are added at the feed end of the scalper cells. Scalper tailings are discarded, and the cleaner concentrate constitutes the LPF product, which is composed of precipitated copper and finely divided sulfide copper minerals which were contained in the slime.

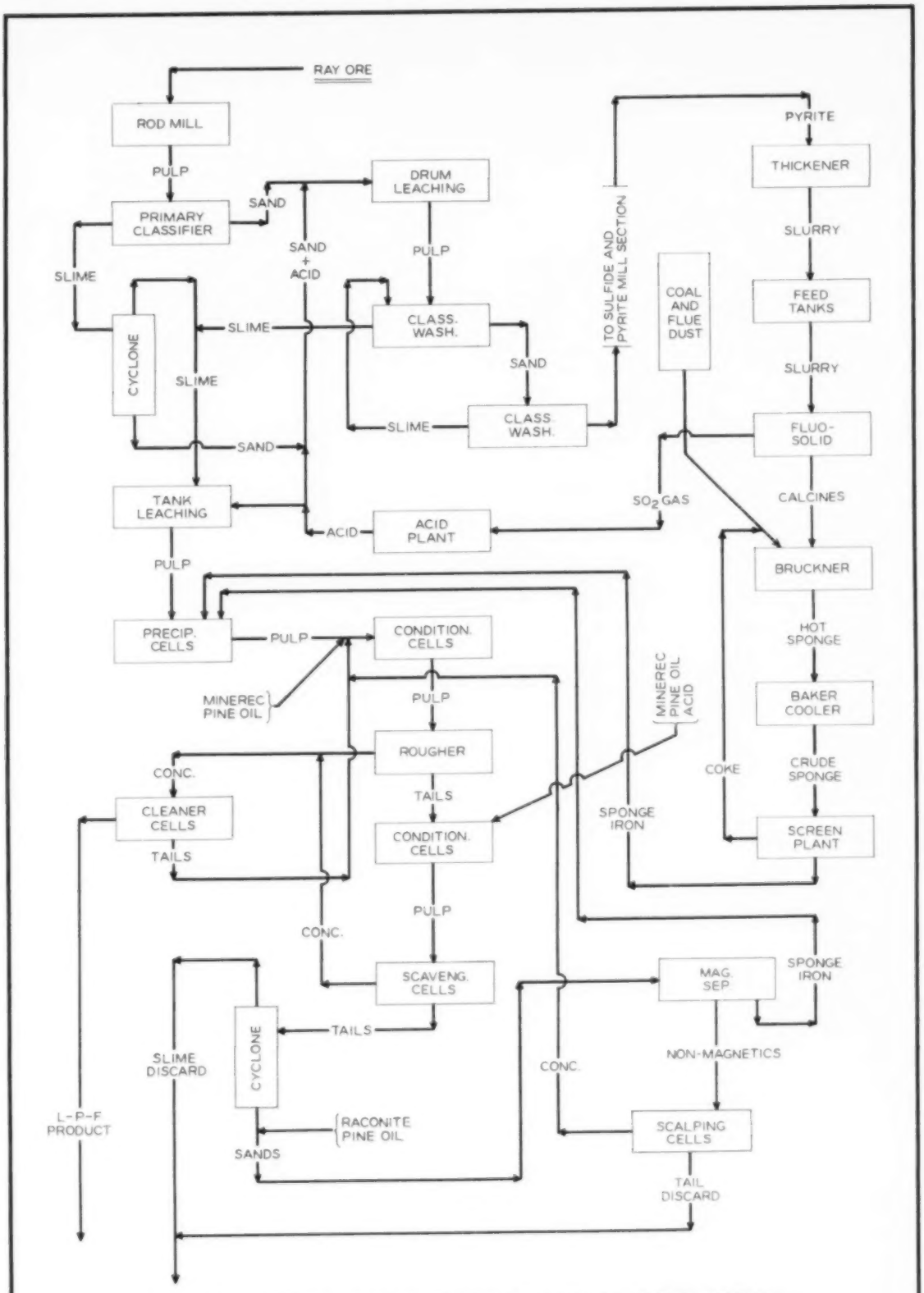
Operating data and control

Approximately 16,000 tpd of Ray ore is treated in the Hayden concentrator of which about 3500 tpd reports as slime to the LPF circuit proper. Heads to the LPF circuit range from about 0.5 to 1.25 gpl of copper in solution. Flotation reagent consumption is normal. Acid consumption is about 8 lb per ton of mill feed. Sponge iron consumption is about 4 lb per ton of mill feed. Since the amount of copper going to the LPF circuit varies, the operators determine by hourly colorimetric assays the quantity of sponge iron required and make adjustments accordingly. Acid consumption is controlled by pH recorders and controllers placed ahead of the leach tank. Automatic sampling stations provide representative samples at several critical stages in the circuit.

Since the LPF process has been installed, about two years operating experience has been obtained. This operating data has been used as a basis for making continued improvements, but very little in the way of basic metallurgy has been changed.

Reference

[1] A. W. Last, J. L. Stevens, and L. Eaton, Jr: LPF Treatment of Ray Ores, Mining Engineering, Nov. 1957, vol. 9, pp. 1236-1238.



FLOWSHEET OF THE RAY L-P-F PROCESS

1958 INCOME SURVEY of Members of The Metallurgical Society of AIME

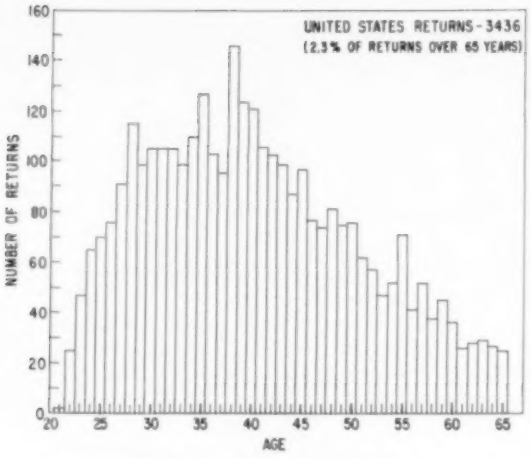


Fig. 1—Distribution of US returns according to age.

Here is an analysis of the recently completed income survey of The Metallurgical Society of AIME, conducted by a special sub-committee of the Committee on the Metallurgical Profession. Members of the sub-committee are:

F. W. Starratt, Journal of Metals,
S. G. Fletcher, Latrobe Steel Co.,
W. R. Opie, National Lead Co., and
D. L. Wood, General Electric Research Laboratory.

Analysis of the data and preparation of this report was carried out under the direction of D. L. Wood.

As a service to the profession, The Metallurgical Society of AIME has conducted a survey of the incomes of its members. The object of the survey is to present in as much detail as possible the income structure of the Society, and to examine the influence of certain variables on this structure. It is hoped that this initial survey will lay the ground work for future surveys and serve to define more clearly the problems encountered in such studies.

It must be pointed out that results reported herein are not necessarily representative of the metallurgical profession, since they refer only to the incomes of Metallurgical Society members. In particular, results refer only to members who participated in the survey and there is uncertainty with respect to the degree to which this specific sample represents The Metallurgical Society.

Nature of the survey

A questionnaire was designed to obtain information concerning those variables which appeared important in considerations of income. In particular, age, years of experience, type of business, primary type of work, major function, and academic degree seemed likely to be related to the income structure. By type of business is meant the industrial interest of an organization, such as ferrous metals production or chemical or electrical business. Primary type of work refers to the particular area of a business in which a person is directly involved, such as engineering, sales, or research. The major function of an individual is defined as the manner in which he makes his contribution to the profession, as a manager, a consultant or as a teacher, for example.

A questionnaire was mailed with an explanatory letter to each member of The Metallurgical Society. Returned questionnaires were examined for validity and completeness. Information contained on the questionnaires was key punched on IBM cards in a manner that enabled a determination, by the IBM machine, of the distribution of returns according to particular variables or any combination of variables. It was possible, for example, to obtain a chart showing the distribution of incomes according to age for any given population. From such charts, points could be calculated which denoted upper decile, median, and lower decile incomes. When the number of returns in a given analysis was less than about 500, however, only median points could be calculated. These points were calculated for every three-year interval and plotted at the middle year of that interval.

This was accomplished by starting at the earliest three-year interval, and moving the interval only one year at each step. Each point, therefore, is

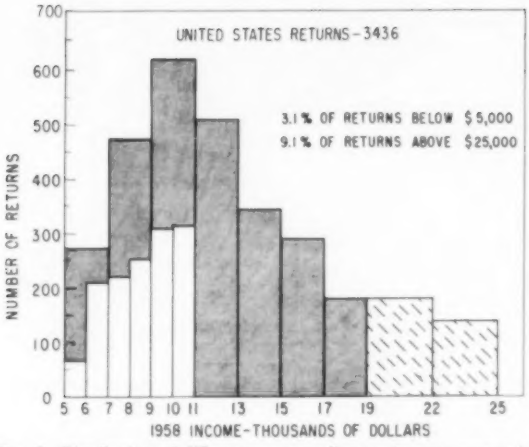

UNITED STATES RETURNS-3436
3.1% OF RETURNS BELOW $5,000
9.1% OF RETURNS ABOVE $25,000
NUMBER OF RETURNS
1958 INCOME-THOUSANDS OF DOLLARS

Fig. 2—Distribution of US returns according to income ranges in the questionnaire. (Since the size of the range was not the same for all income levels, the $1000 ranges at the lower end,—clear bars —have been combined to form $2000 ranges—heavily shaded bars. The $3000 ranges at the upper end of the distribution are lightly shaded.)

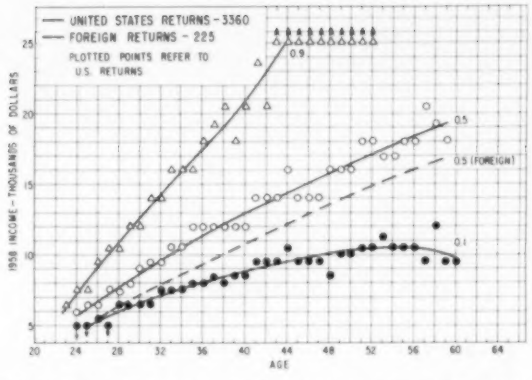


Fig. 3—Upper decile (0.9), median (0.5), and lower decile (0.1), curves of income as a function of age for all US returns, and median curve for all foreign returns.

representative of the population contained in a three-year interval. Data points are included in Fig. 3 as an example of the amount of scatter common to the analysis. Curves of best fit were drawn through the points. Some difficulty in smoothing the curves resulted from the fact that incomes were reported only within ranges, and in processing the data it was necessary to assume that the average of the incomes of all the returns in any given range was at the midpoint of that range.

A general analysis of incomes was made with respect to all returns. The analysis was then extended to certain groups according to type of business, primary type of work, major function, and academic degree. In some instances the number of returns in a given group was sufficient to allow further analysis within the group.

Analysis was then made, for example, of particular types of work within given businesses, of particular primary functions within given types of work, and of particular academic degrees in given primary functions. The extent to which analyses could be made in such break-downs was determined by the limit of statistical significance of the calculated points as imposed by the number and distribution of the returns involved. Generally, if the number of returns in a break-down was greater than about 150, median curves could be calculated.

In most of the analyses, income was considered as a function of age. Survey returns indicated uncertainty about the meaning of *years of experience*, and no data are presented as functions of that quantity. Other salary surveys have shown that there is little distinction between *years since bachelor's degree* and *years since age 22*, and this relation is borne out by this survey. In analyses which were concerned with academic degree, however, calculations were made not only as a function of age, but also as a function of years since certain academic degrees.

Distribution of returns

Of 7000 questionnaires mailed to members of the Society, 3772 or 53.9 pct were returned, but 111 returns from students, members of the military service, retired persons, etc. were considered special cases and were not included in the analysis. Of the remaining 3661 returns, 225 were from foreign countries. The foreign returns, except for Fig. 3, were not included in subsequent analyses. The 3436 returns from within the US were distributed geographically as follows: Eastern States, 49.4 pct; North Central States, 25.9 pct; Pacific Coast States, 9.4 pct; Rocky Mountain States, 6.5 pct; Southern States, 4.4 pct; and Middle Western States, 4.4 pct.

As a preliminary step in the analysis, a determination was made of the distribution of returns according to age and according to income. Fig. 1 shows the number of returns for each age. The youngest non-student to reply was 21; the oldest was 85. Fig. 2 shows the distribution of returns among the income ranges provided for in the questionnaire; these ranges are denoted by the numbers at the bottom of the graph. The heavily shaded area, which is in part a combination of the smaller ranges, shows that the peak of the distribution occurs in the income interval of $9,000 to $11,000.

Results of the analysis

a) General

Consideration of all the returns as a single group, with no distinction as to business, work, function, or degree, results in the curves shown in Fig. 3. As an example of the interpretation of such curves, and considering all those US participants in the survey whose age is 40, 10 pct had incomes in 1958 of less than $8,800; 50 pct had incomes of less than $13,000; and 90 pct had incomes of less than $21,000.

For comparison purposes, the salary curves published by the Engineers Joint Council in January, 1959 for professional people of all degrees in all types of industry are shown in Fig. 4 together with the current survey results. The evident disparity of the sets of returns demonstrates substantial differences between the two population sets.

b) Type of business

The questionnaire distinguished between the following types of business: educational, chemical, automotive or machinery, nuclear, aircraft or missile, research, ferrous production, nonferrous production, electrical or electronic, and other metal fabrication.

The number of returns was sufficient for the calculation of upper and lower decile curves only for the ferrous metals production and nonferrous metals production businesses, Fig. 5. These curves

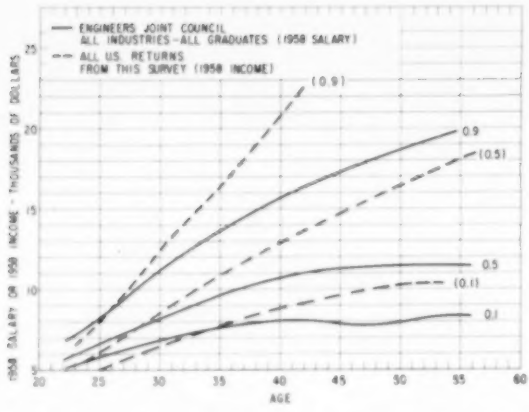


Fig. 4—A comparison of salary-versus-age curves drawn by the Engineers Joint Council for all graduates in all industries with curves of Fig. 3.

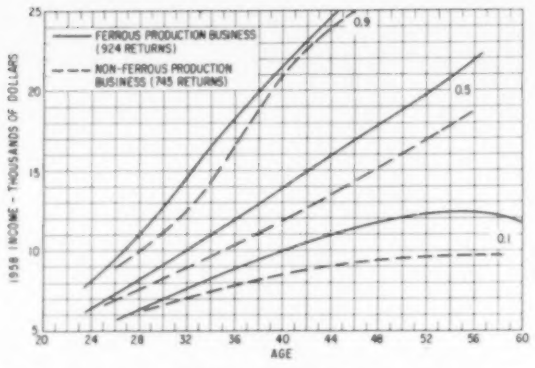


Fig. 5—Income as a function of age for both the ferrous production business and the nonferrous production business.

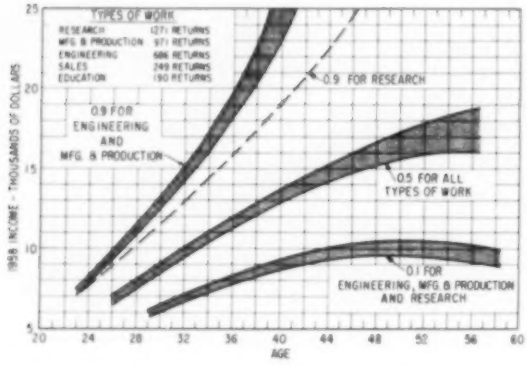

TYPES OF WORK
RESEARCH 127 RETURNS
MFG. & PRODUCTION 971 RETURNS
ENGINEERING 606 RETURNS
SALES 249 RETURNS
EDUCATION 190 RETURNS
0.9 FOR RESEARCH
0.9 FOR ENGINEERING AND MFG. & PRODUCTION
0.5 FOR ALL TYPES OF WORK
0.1 FOR ENGINEERING, MFG. & PRODUCTION AND RESEARCH
1958 INCOME - THOUSANDS OF DOLLARS
AGE

Fig. 6—Income as a function of age for various types of work.

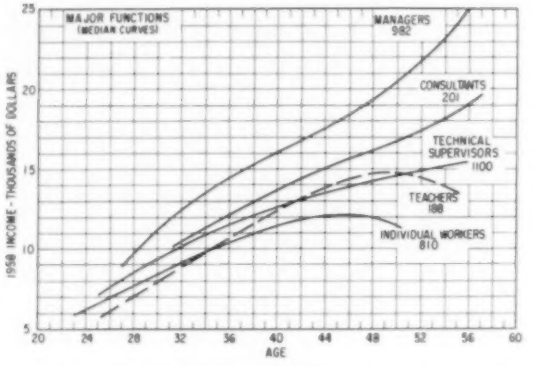


Fig. 7—Median curves of income versus age for major functions.

indicate that the median and lower decile populations of the ferrous production business earn more than those in the nonferrous production business. The upper decile population, however, particularly beyond about age 38, is not significantly different in the two businesses. The medians for the research, nuclear, aircraft or missile, chemical, and automotive or machinery businesses are found to lie between the median curves in Fig. 5; that for the electrical or electronic business is slightly higher, and that for the educational business is slightly lower.

c) Type of work

The types of work considered in this survey were engineering, manufacturing and production, research, education, and sales. The number of returns was sufficient for calculation of upper and lower decile curves for all types of work except sales and education. As is shown in Fig. 6, the medians for all types of work are approximately the same, and lie within the shaded band. A similar statement applies to the lower decile curves for engineering, manufacturing and production, and research work. The upper decile curve for research work, however, is below that for either engineering or manufacturing and production work. This difference, however, is probably significant only beyond about age 34.

In an attempt to analyze particular types of work within a given business, it was found that only in the ferrous production and nonferrous production business was the number of returns large enough for this consideration. Analysis showed that the median curves for engineering work, manufacturing and production work, and for research work in the ferrous production business were similar and correspond to the median curve for the ferrous production business shown in Fig. 5. A similar relationship was found for these types of work within the nonferrous production business.

d) Major function

Although the questionnaire was intended to distinguish the functions of manager, technical supervisor, individual worker, consultant, and teacher, it is probably true that a common understanding of the definition of these various functions did not exist among the participants in the survey.

This problem is complicated not only by the difficulty of defining various functions such as those of manager and technical supervisor, for example, but also by the fact that an individual may perform a variety of functions. This is evidenced by the considerable number of participants who indicated more than a single function. The number of returns which were not in question as to function, however, was large enough to enable an analysis on this basis. Only for teachers and consultants was the number of returns too small for the calculation of upper and lower decile curves.

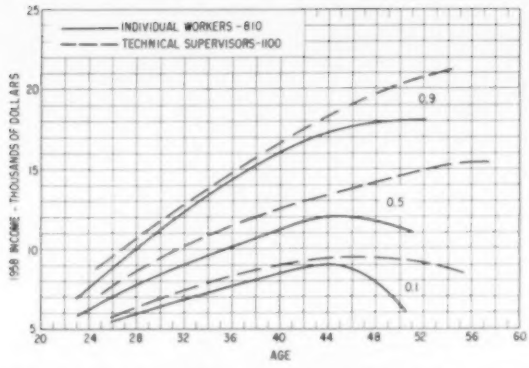


Fig. 8—Income as a function of age for individual works and technical supervisors.

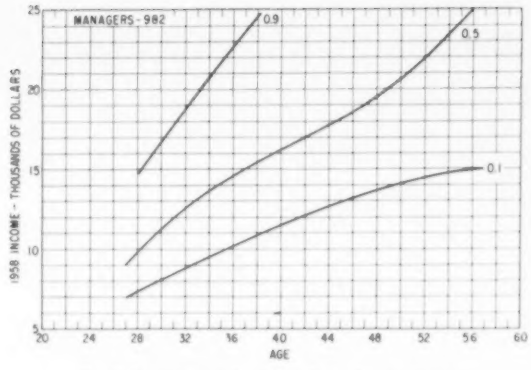


Fig. 9. Income as a function of age for managers.

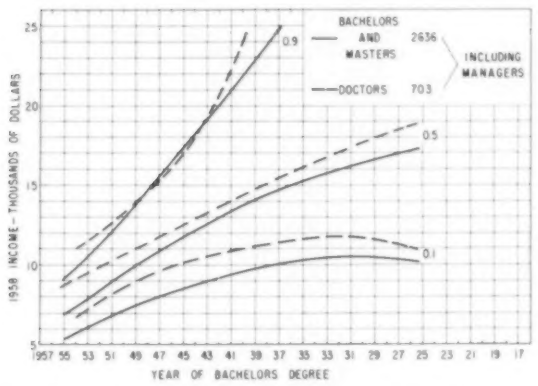


Fig. 10—Income as a function of year of bachelor's degree for doctors and combined bachelors-masters, including all managers.

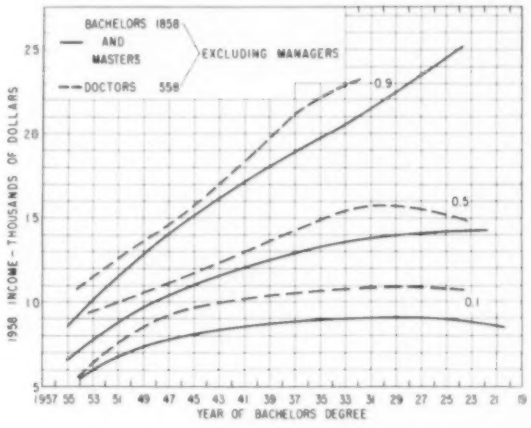


Fig. 11—Income as a function of year of bachelor's degree for doctors and combined bachelors—masters, excluding all managers.

The median curves of income versus age for the various functions are shown in Fig. 7. The difference between the curves for individual workers, teachers, and technical supervisors, at least up to about age 42, is not appreciable. The curve for consultants, however, is significantly higher than that for individual workers, while the curve for managers is appreciably higher than that for any of the other functions.

Further analysis of the income structure of managers, technical supervisors, and individual workers is shown in Figs. 8 and 9. Fig. 8 shows that the upper and lower decile curves for technical supervisors and individual workers are essentially the same. Fig. 9 shows that the lower decile curve for managers is not appreciably lower than the median curve for technical supervisors or individual workers from Fig. 8, and that the median curve for managers corresponds quite closely to the upper decile curve for technical supervisors and individual workers.

It was possible to analyze the income structures of particular primary functions within certain types of work. The income structures of technical supervisors in engineering work, manufacturing and production work, and research work were found to be quite similar and to be insignificantly different from that structure shown for this function in Fig. 8. An analysis of income structure of individual workers in these types of work gave a similar relationship.

e) Academic degree

The returns included 97 with no degree, 2101 with bachelor's degrees, 535 with master's degrees, and 703 with doctor's degrees. Since a preliminary analysis showed that income curves as a function of age calculated separately for bachelors and masters were generally indistinguishable, the returns from these two groups were combined into a single group for further analysis.

In consideration of the relation of academic degree to income structure, the question arises as to whether the correct variable is age or, effectively, years since a given academic degree. In this survey separate calculations were made for each of these variables. It will be shown that, in fact, curves calculated on the basis of age can be made to superpose on the curves calculated for the same population on the basis of year of obtaining a given degree, if the age at receiving the degree is correctly chosen.

Fig. 10 shows upper and lower decile and median curves for bachelors-masters and for doctors plotted against year of bachelor's degree. These curves, which include managers, indicate that the upper decile populations have nearly the same income regardless of degree, while the median and lower decile curves maintain a rather constant difference which may be related to starting incomes. The curves in Fig. 11, which exclude managers from the population considered in Fig. 10, show a similar

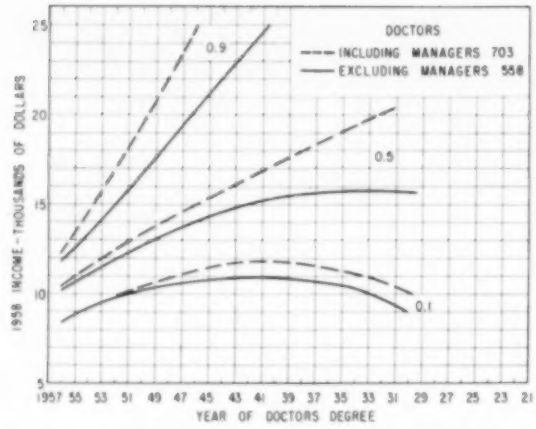


Fig. 12—Income of doctors as a function of year of doctor's degree.

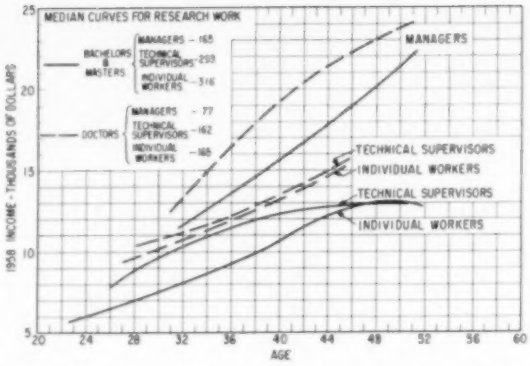


Fig. 13—Median curves of income versus age for doctors and for bachelors-masters with various functions in research work.

relation of academic degree to income. The median and upper decile curves for this non-managerial population are generally shifted downward from those in Fig. 10 which include managers.

The incomes of bachelors-masters and of doctors calculated as a function of age can be made to superpose on the appropriate curves in Fig. 10 and 11, if the age at receiving the bachelor's degree is set at about 22 years.

Fig. 12 shows the income of doctors as a function of the year in which the doctor's degree was obtained. The income curves of this group calculated as a function of age superpose on the appropriate curves in Fig. 12, if the age at receiving the doctor's degree is set at about 29 years. The accuracy of this superposition is checked by the fact that the curves of Fig. 12 are displaced from the appropriate curves on Fig. 10 and 11 by about seven years, indicating an interval of about seven years to the doctor's degree from the bachelor's degree at age 22.

There is an apparent discrepancy between this observed interval from bachelor's to doctor's degree and the generally accepted average of three to four years. It must be pointed out that the seven year displacement is an average shift which results in the best overall superposition of the curves. Particular observations of Fig. 11 and 12 show that this displacement is less in the more recent years.*

* This can be seen by selecting a year of doctor's degree from Fig. 12, noting the median income for that year, and determining the year of bachelor's degree (Fig. 11) that corresponds to that particular median income. For the non-managerial doctor who received a doctor's degree in 1946, for example, the median income from Fig. 12 is $14,000; from Fig. 11 this median income corresponds to 1938 as the year of bachelor's degree. Hence, an effective interval between the bachelor's and doctor's degree of about eight years. At the year 1954 for the doctor's degree, the interval is about six years. If the necessary extrapolation is made, it appears that at the year 1958 for the doctor's degree, the interval is about four years.

This might be explained by military service between degrees, or by the failure of the rate of income growth after obtaining the doctor's degree to keep pace with the rate of increase in initial incomes.

An analysis of academic degree with respect to various functions could be made only in research work. Fig. 13 shows median curves of income versus age for bachelors-masters and for doctors in various functions in research work. The curves for doctors are significantly higher than the corresponding curves for bachelors-masters. Essentially no difference is found in the income structure of doctors who are either technical supervisors or individual workers in research; a difference does exist, however, for these two functions in the bachelors-masters group.

Concluding remarks

This report is intended to present the income structure of The Metallurgical Society and the way in which this structure is influenced by type of business, primary type of work, major function, and academic degree. The extent to which this structure is representative of the Society is uncertain, however.

Shortcomings of the techniques used in this study have been indicated throughout the report. A major difficulty resulted from the reporting of incomes within rather coarse ranges. More accuracy in analysis might have been obtained if incomes had been reported to the nearest one thousand dollars. Confining the upper range of income to $25,000 restricted the calculation of some of the upper decile curves to a rather short interval of ages.

There is obviously a need in such a survey for a clear, common understanding among the participants as to the definitions of the variables contained in the questionnaire. The least common understanding in this survey appeared to be with respect to *major function* and *years of experience*.

The inclusion of precise geographical location data on a questionnaire in a survey of this type seems to be of little value. The many variables associated with precise geographical location appear to preclude any analysis of its influence on income structure.

Although the return from the Society members was encouraging, a more statistically significant survey would have been possible if a larger fraction of members had participated. It is hoped that resolution of problems described herein will lead, not only to the establishment of more accurate and efficient techniques for future surveys, but also to a more extensive participation by the membership.

Appreciation is expressed to Dr. W. R. Hibbard, Jr., who, as President of The Metallurgical Society, proposed the survey described herein and who extended guidance and encouragement throughout the study.

THE 1959 NUCLEAR CONGRESS

Progress in reactor development—both nuclear and thermonuclear—as reported at this year's Nuclear Engineering and Science Conference and Atomic Energy in Industry Conference.

A Staff-Written Summary

Over 250 papers on peaceful uses of atomic energy were given at the Fifth Nuclear Congress, held in Cleveland, April 5th to 10th. Coordinated by Engineers Joint Council and sponsored by 30 leading engineering and scientific societies, the Congress consisted of four parts: the Nuclear Engineering and Science Conference, the Hot Laboratories and Equipment Conference, Atomic Energy in Industry Conference, and the AtomFair.

Progress in fusion

Fusion processess was a topic discussed by one of the leading authorities in this field, Arthur E. Ruark, US Atomic Energy Commission. He pointed out that, until recently, little emphasis had been given to nuclear energy from fusion because of the relatively abundant energy sources in the US. Uranium supplies are ample, and little need is felt to move into this more-difficult-to-solve realm of energy from the atom. It is only from a long-range point of view that the present program is being undertaken. But if successful, the process can produce vast quantities of energy with negligible fuel costs. Such energy, it is claimed, could be converted directly into electricity with high thermal efficiency. Some 400 scientists and engineers, working with a budget of $36 million are now engaged in the nuclear research in the US.

For fusion of atomic nuclei to take place, an ionic plasma must be brought up to the ignition energy level. Several approaches are now being used: the pinch effect at Los Almos, the Stellerator at Princeton, the mirror effect at Livermore, and the high-injection technique at Oak Ridge. Much progress is being made by each of these approaches. The goal is an energy level of 40 million degrees; two years ago the highest level achieved was on the order of 1 million degrees, while today levels of 10 million degrees have been reached.

After his lecture Dr. Ruark showed pictures of soft X-rays produced at Los Alamos by the radiation of plasma at the 10 million degree level. This, according to Dr. Ruark, indicates that some thermonuclear processes have actually been achieved. Further progress is being made at each of these four sites. At the Forrestal laboratory at Princeton University, for example, a Stellerator four times larger than the present unit is being built.

Reactor design

A significant portion of the programs of both the Nuclear Engineering & Science Conference and the Atomic Energy in Industry Conference was devoted to the potential of various reactor designs now under study, particularly their economic factors.

Five to eight mil power predicted for OCDR

Perhaps the most startling prediction concerning power costs was made by M. J. McNelly of Canadian General Electric Co. Ltd. He explained that a 250-mw organic-cooled, deuterium-moderated reactor could be built and operated today, producing power for 4.9 to 7.8 mils per kw-hr, depending on the capital charge rate. This figure assumes an 80-pct load factor, considered feasible with this type of reactor. Among the advantages that Mr. McNelly listed for an organic-cooled deuterium reactor (OCDR) were the following:

Higher thermal efficiency: Coolant temperatures around 800°F can be tolerated in the OCDR, because vapor pressure of the organic coolant is still small at that temperature; operating costs do not go up appreciably until bulk temperatures above 800°F are encountered; and temperature distribution within the ceramic UO_2 fuel element (melting point: aprox. 5000°F) is not seriously affected by an increase of a few hundred degrees.

High specific power rating: Although some neutron economy is lost and poison load is increased, operation at a high specific power output is desir-

Massive concrete and structural steel beginning to give shape to the Consolidated Edison Co.'s nuclear generating station at Indian Point, N. Y. Constructed by the Babcock & Wilcox Co., the completed nuclear facility will generate 275,000 kw.

able if capital costs are to be kept low. The OCDR unit is designed to produce 490 mw of thermal power with a load of 6.6 x 10^4 litres D_2O and 32.4 tons of UO_2. This gives a power rating of 7.45 kw per litre of D_2O or 15.1 mw per ton of UO_2. This is possible due to the separate moderator and coolant circuits which permit the use of high-coolant velocities and a precise heat transfer design.

Low nuclear inventory: The elimination of heavy water from the coolant circuit results in substantial reduction in the amount of capital tied up in nuclear materials. Total costs for fuel in the 250-mw reactor are estimated at $31 per kw.

Low fueling costs: The method proposed for feeding fuel through the reactor would give no portion of the charge more burnup than 6000 mw-days per ton of uranium, and at an overall station efficiency of 31.4 pct, refuelling costs are calculated at 1.57 mils per kw-hr. Further cost reductions using slight enrichment of the fuel appear possible.

Radiation damage costs: Due to the presence of a heavy-water moderator in the core, the organic coolant receives much less of the radiation energy than in a reactor where the organic fluid both moderates and cools. This minimizes radiation damage to the coolant.

Total capital costs for OCDR are estimated at $285 per kw, with operating costs set at 2.1 mils per kw-hr. Thus, at a load factor of 80 pct, such an installation should produce power for 5 to 8 mils, depending on the interest rate (7 and 14 pct used to get the above figures). Such costs indicate that this type of reactor should receive a more prominent place in US reactor development plans than it has had to date.

Gas-cooled reactors

D. F. Shaw, Kaiser Engineers, reported that gas-cooled reactors of the 200 to 225-mw size range could produce power for 13 to 15 mils per kw-hr, which compares favorably with published results on boiling water and pressurized water reactors. Helium is favored as the coolant gas, but use of hydrogen is seen as a possibility for further cost reductions.

Pressurized water reactors

High steam pressures and low cost materials have visibly brightened the outlook for low-cost power from pressurized water reactors, according to C. T. Chave, Stone & Webster Engineering Corp. Increasing steam pressure from 500 to 1050 psi results in thermal efficiency increasing from 28 to 34.5 pct. Although this necessitates higher cost turbine equipment, economic gains outstrip the expenditures. Mr. Chave stressed that many economies could be effected by careful design, using the minimum materials. There has been too much of a tendency toward designing for unlikely, unforseen emergencies where statistical risk can and should be taken as to availability, but not, of course, to public safety. Use of carbon steel and thin-wall stainless piping should be emphasized.

Fossil fuel superheating has always been recognized as a method of cutting overall costs markedly, and this should bring combination-type plants into competition very soon, in industrial areas.

Liquid fuel reactors

Although admittedly not competitive on a short-term basis, fluid fuel reactors hold much promise in the long run, because of their ability to achieve lower fuel cycle costs and higher neutron economy than solid fuel types, according to J. A. Lane, Oak Ridge National Laboratory.

While low fuel cost is an important economic factor, high neutron economy has even more far-reaching effects. This is due to the fact that a high neutron efficiency is necessary to sustain the thorium breeding cycle, a cycle which will one day be most important in conservation of uranium resources.

It is estimated that fluid fuel reactors may have as much as 0.15 neutrons per fisson margin over solid fuel systems. For example, if 30 pct of the reactors built after 1980 were of the low-inventory, thorium breeder type, this would mean a saving of about 170,000 tons of natural uranium by the year 2000—amounting to more than $4 billion. Thus, it would seem that continued development is definitely warranted, so that both economic and breeding potential of this type of reactor may be assessed accurately.

Fuel elements

Metallurgy of nuclear fuel elements was the major topic of discussion at that part of the Nuclear Engineering and Science Conference sponsored by the AIME. Factors affecting sinterability of refractory oxides, and problems of bonding and forge rolling of Zircaloy were among the topics discussed.

Sintering

It is well known that sintering of UO_2 compacts and cooling in a hydrogen atmosphere can increase thermal conductivity up to 25 pct. R. B. Winkler, Mallinckrodt Chemical Works, reported that micronized UO_2 exhibited the highest sintered density of any powder compact. Its density reached nearly 95 pct on some specimens, after extrusion or cold pressing. It was also reported that extrusion yielded definitely better dimensional control than was obtained in the pressed compacts.

A study into the mechanism of sintering was made by R. Chang, Atomics International. He reported that a diffusion mechanism predominates during the initial sintering of crystalline solids. At high sintering temperatures, a volume diffusion mechanism following the required fifth power law takes place, while at low temperatures, grain-boundary or surface diffusion may be important; a specific mechanism is required for each sintering process.

Mechanisms leading to densification and pore-shrinkage during the later stages of sintering are more complicated than those governing the initial stage, and further work should be directed toward establishing what conditions are necessary for each sintering process.

Bonding problems

Zircaloy-2 is an attractive cladding material for UO_2 platelets, and a successful process of diffusion-bonding has been developed, which employs a eutectic mixture of zirconium with copper, iron, or nickel in the bond region. As a result of studies carried out at Westinghouse's Atomic Power div. laboratories, nickel eutectic alloys have been eliminated from this group. It was found that, when exposed to corrosion media, nickel-enriched samples absorbed 10 times more hydrogen than ordinary Zircaloy-2, and that, in the presence of both cor-

rosion media and irradiation, nickel-enriched material absorbed 100 times more hydrogen than the pure alloy. This resulted in severe embrittlement, several samples having cracked during tests.

It is theorized that nickel content enhances hydrogen absorptivity by decreasing the adhesion of the ZrO_2 film, catalyzing hydrogen attack of the oxide film, and altering the defect structure of the film so as to raise its solubility.

Irradiation is postulated as creating lattice defects which enhance solubility for hydrogen, and as causing ions, radicals, or other species in the environment which increase the hydrogen potential for the metal. Reduction of nickel content is the obvious solution to this problem, and current diffusion-bonding is concentrating on the copper and iron eutectics. However, it was also found that corrosion testing prior to irradiation and certain heat treatments also reduced hydrogen absorption.

Successful hot isostatic pressure bonding of Zircaloy-2 and aluminum to various uranium alloys was reported by J. Fugardi and J. L. Zambrow, Sylvania-Corning Nuclear Corp. Conditions for a good bond are 1200°C temperature and 12,000 psi pressure for a period of 20 min, provided that all surfaces are clean and a leak-tight container is used. The process is also applicable to metal-ceramic bonds, such as are necessary in ceramic fuel elements. The conditions described exceed minimum conditions for good bonding, and current work is being directed toward establishing such minimums.

Forge-rolling process for Zircaloy

Zircaloy-3 recessed cover plates have been produced by a forge-rolling process with reproducible dimensions and within reasonable tolerances. The process was developed by a group at Clevite Research Center, headed by R. D. Johnson.

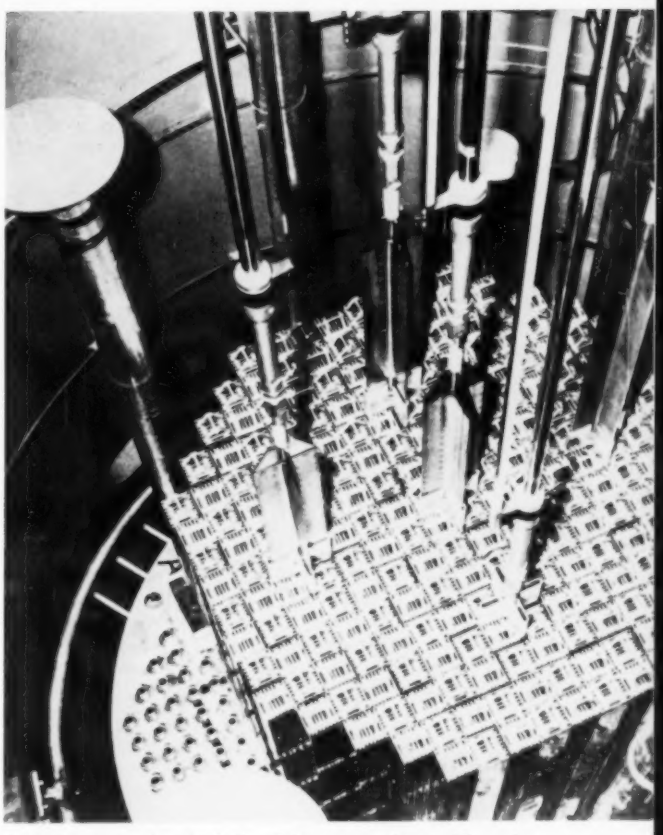
A single-pass system was found to be unsatisfactory, due to the limited cavity depth obtainable and the lack of vertical cavity walls. A two-pass system provided a shape in the initial pass that was amenable to uniform reduction of cross section across the entire surface in the second pass. While scrap losses in the process approximated those experienced in conventional machining methods, it is expected that predetermined stock sizes and proper feeding into the mill should produce excellent indented cover plates with much greater economy.

Testing radioactive elements

Use of ultrasonics has been well established for non-destructive testing of uranium fuel elements before placing them in reactors, but the use of such equipment for testing elements after irradiation is a recent practice, according to J. M. Fouts, who has been doing such work at the Hanford plant.

Elements with an activity approaching one-million roentgens per hr, are placed on rollers under 10 ft of water, and scanned as they are rotated. Power for the rotation is obtained from electric motors located above the water on a platform. The element is also scanned longitudinally while rotating.

The instrument is designed to test the bonding integrety between the core and the cladding material, and is calibrated regularly with standards of known bonded and unbonded areas. Testing of this type is planned to aid studies of bond stability and possible correlation with localized hot areas in reactors.



Critical test core for the Indian Point reactor shown while undergoing tests at Babcock & Wilcox Co.'s Critical Experiment Laboratory near Lynchburg, Va.

H. F. York addresses banquet

The well-attended All-Congress Banquet, held on Wednesday evening, April 8th, featured a double-level dias filled with dignitaries from European nuclear agencies, as well as the sponsoring engineering and scientific societies. AIME President-Elect Joseph L. Gilson, and Engineers Joint Council President Enoch R. Needles, were among them.

Speaker of the evening was Herbert F. York, director of research and engineering of the US Dept. of Defense. He recounted the events leading up to the now-famous ARGUS experiments held in the south Atlantic during 1958. Impetus for this massive experiment began at the Berkeley and Livermore, Calif., radiation laboratories several years ago when scientists began exploring means of controlling the release of thermo-nuclear energy. A mirror machine, modeled after the apparent mirror effect in the movement of charged particles in the earth's upper atmosphere, was one technique suggested. Studies of high-level explosion of an atomic bomb and the detection of the resulting radiation by satellites fired to similar altitudes answered many questions about the earth's natural mirror effects. Only now are scientists beginning to pull together all of the facts from this experiment and extrapolate the earth's magnetic field into space.

WHAT HAPPENED IN ST. LOUIS?

Blast-furnace and open-hearth men poured in for the 42nd Annual Conferences of the National Open Hearth Steel Committee and the Blast Furnace, Coke Oven, and Raw Materials Committee. Here is the story of what took place.

OLE Man River called blast furnace and open-hearth man down along the Mississippi to St. Louis . . . in all, 1588 registrants . . . the dates, April 6th to 8th . . . the occasion, the Forty-second Annual Conferences of the National Open Hearth Steel Committee and the Blast Furnace, Coke Oven, and Raw Materials Committee.

Sessions were held in the Sheraton-Jefferson Hotel, but for those who ventured beyond the hospitality suites, the color of the old river port was absorbed with delight. Spring . . . or maybe summer . . . was in the air with temperatures rising into the high seventies.

We regret to report the unavoidable absence of three leading figures behind the conferences: Leo F. Reinartz, former AIME President and conference founder, R. E. Powers, Vice Chairman of the Blast Furnace, Coke Oven, and Raw Materials Committee, and V. W. Jones, Chairman of the National Open Hearth Steel Committee. Vice Chairman D. R. Loughrey thus took charge of the major open-hearth functions.

Open-hearth sessions

On Monday morning, April 16th, open-hearth sessions got underway with the presentation of the McKune Award paper by its author, G. M. Hagenberger of the Standard Steel Works div., Baldwin-Lima-Hamilton Corp., Burnham, Pa. Title of the paper was *Conversion to 70 pct Natural Gas Utilizing a Continuous Oxygen and Combustion Analyzer.* Making use of newly available supplies of natural gas . . . a lower cost fuel . . . the open-hearth department of this plant set about resolving the problems of firing natural gas without altering the furnace design. Instead of using natural gas as an atomizing agent to replace endothermic steam, the potential economic advantages of natural gas appeared to be more promising when the gas was fired as the primary fuel, supplemented by liquid fuel. Mr. Hagenberger concluded: "The conversion and operation proved far more smooth and trouble-free than initially anticipated, and the 23 pct lower fuel cost, amounting to $0.80 per net ton charge, exceeded expectations. The oxygen and combustibles analyzer was the first installed on an open-hearth furnace . . . and . . . after considering the advantages and economical benefits resulting from the analyzer, the decision was made to purchase four additional units to equip all the open hearths in the department."

With so many interesting papers presented at the Open-Hearth Conference, it is difficult to single out those which deserve special mention. One deserving

K. Kasai of Sumitomo Metal Industries of Japan delivers the JOURNAL OF METALS Award paper. Photo courtesy Laclede Steel Co.

paper appears to be *Control of Chemical Composition: A Practical Program for the Control of Open Hearth Chemistry*, by T. D. Hess and R. L. Kimberly of Youngstown Steel & Tube Co. The authors pointed out that:

"We have not yet found the curve for off heats! Statistics show that we have made a good start at reducing the problem, but there is still much work to be done.

"A survey revealed that almost 75 pct of our [Youngstown's Indiana Harbor works] off heats were missed in two elements, carbon and manganese . . . The approach used to the carbon problem was standard with nothing very unique about it . . . The manganese problem is quite a different matter . . . Basically, there are three reasons why heats are missed in manganese: wrong heat size . . . wrong amount of manganese used . . . and . . . recovery variation." In regard to the first cause, actual heats "were heavier than our method of calculation showed them to be. The reason for this turned out to be that we were undervaluating the weight of the metallics recovered from the charge ore." Further improvements resulted when, "more attention was paid to checking the accuracy of the scales, the techniques of weighing, and particularly, more frequent tare weighing of buggies . . . Also, on the subject of weights, some changes made in the handling of stock for finishing and deoxidation should be mentioned. Formerly, ferroalloys were received in bulk, but mainly to solve a materials handling problem, these now come palletized. Our 4000 lb silico manganese block, for example, used to be weighed up from loose material in a bin. Now our silico manganese is packaged by the supplier in 4000 lb lots. We still weigh the material but we now have a double check of the weights.

"In checking back over the heat logs of missed heats, it was sometimes very difficult to understand how the melter arrived at the particular dose of manganese that was used. After talking with the melters, it soon became apparent that among eight different melters, there were eight different ways of calculating heats, ranging from complicated systems . . . down to using the same *dose* that was used on the last heat made to the specification in question. Some of the melters had very good systems, however, including the use of information put up in tabular form.

"What was needed was a standard method of figuring heats, to get everyone thinking in the same terms. It had to be simple, fast, and with as much as possible of the arithmetic done in advance. We came up with a standard work sheet to be used in conjunction with a series of tables. These not only include manganese but the other more common elements of importance in finishing the heat.

"Of the three causes of off-heats, the least progress has been made in the causes of recovery variation . . . The biggest single factor affecting manganese recovery is whether the manganese is added to the furnace or the ladle. Ladle additions of manganese yield higher recoveries, and, what is more important, more uniform recoveries than manganese furnace additions. There are fewer variables acting in ladle additions.

"The best answer we have been able to arrive at for controlling manganese recovery is standardization of steelmaking practices . . . The aim is to make all heats as nearly alike as possible, which in effect neutralizes the variables by converting them to constants.

"The first steps in the project of reducing off heats were undertaken in December of 1956. Since then, and right up to the present, new controls were added as they were developed and became available . . . In summary, over the two year period, off-heats were reduced by 25 pct and diverted heats by 40 pct. The program has been particularly effective in almost eliminating bad misses, where the chemistry departs from the acceptable range by a margin."

In the various open-hearth sessions much attention was given to basic brick roofs (In a forthcoming issue, JOURNAL OF METALS expects to publish a summary of these developments written by A. H. Sommer, Keystone Steel & Wire Co.) and combustion practice. A review of the *Use of Oxygen in Steelmaking* prepared by Prof. T. B. King, Massachusetts Institute of Technology, and presented by Prof. John Chipman in the former's absence, created a good deal of interest. (JOURNAL OF METALS anticipates publishing this paper in a future issue.)

Blast furnace sessions

While oxygen steelmaking techniques, basic refractories, and methods to increase output through new combustion techniques occupied much of the time of the open-hearth men, those on the blast-furnace side found themselves engrossed in the problems of producing and smelting sinter burdens, particularly self-fluxing sinter, although the utilization of pellets was not overlooked. The paper which won the JOURNAL OF METALS Award, *Making of Self-Fluxing Sinter and the Blast Furnace Practice with Its 100 pct Sinter Burden*, was presented by one of its authors, K. Kasai, Sumitomo Metal Industries in Japan. It created wide interest and will be featured in a forthcoming issue of JOURNAL OF METALS.

Another paper in the same area was *Scottish Experience with Fluxed Sinter*, presented by E. H. Baldwin and I. M. Mathieson of Colvilles Ltd. Their paper concluded:

"In theory the use of sinter fluxed with crushed limestone should give improved thermal economy, and experience on two plants (Clyde and Ravenscraig works of Colvilles) has shown that this can be realised in practice without detriment either to sinter plant or blast furnace operation. For every 100 lb of raw limestone transferred from the furnace burden to the sinter, a reduction in [overall] carbon rate of the order of 26 lb per ton of pig is obtained. Although sinter strength deteriorated somewhat with basicities in excess of 1.5, sinter up to 1.9 has been used quite successfully provided that it was slowly cooled and adequately screened before entering the furnace bin."

A somewhat related subject, ferro coke, was touched upon with the presentation of the paper, *The Production and Use of Ferro Coke*, by G. Granger, M. J. Lach, and J. Mitchell. They pointed out that:

"The production of ferro coke, by incorporating blast-furnace flue dust into a carbonizing mix, and its use as furnace fuel, is a simple, economical means of recovering the iron and carbon in flue dust. Eastern Gas and Fuel Associates have produced ferro coke in standard coke ovens for nearly two years at their Everett [Mass.] plant, and have used it successfully in their Mystic blast furnace. Substantial savings are possible." This technique has provided a "profitable answer to the question of what to do with blast-furnace flue dust." It is also "a useful means of upgrading relatively poor coking coals into usable furnace coke.

"This process should be particularly interesting to the smaller furnace operator who could not economically justify a full-scale sintering plant. It should also be of interest to the larger operator, since it would be a means of expanding the ore throughput in an existing sinter plant by diverting flue dust to the coke ovens. An outstanding advantage of the ferro coke process is that no capital expenditure is involved—one simply uses to better advantage the facilities that are already at hand.

"Our production of more than 60,000 tons of ferro coke in standard coke ovens, and its continued use in the Mystic blast furnace, has been successfully carried out without damage to the ovens or any other equipment. The blast furnace has operated well and produced a large number of desired grades of iron with satisfactory control of specifications. At the present time, the ferro coke amounts to 60 pct of the coke charged in the furnace. We have no reason to believe that higher percentages can not be used. In fact, we expect to use up to 100 pct ferro coke."

The Annual Luncheon and Business Meeting of the Blast Furnace, Coke Oven, and Raw Materials Committee was held on Tuesday, April 7th. J. W. Duncan, Chairman of the Committee, presided. Finance Committee Chairman, W. O. Bishop painted a rosy picture of Blast Furnace finances with over $10,000 in the bank. Nominations, presented by the Committee under the chairmanship of F. W. Hamilton, were unanimously approved, thereby making R. E. Powers the Committee Chairman for 1959.

Annual fellowship dinner

Gathering under a cigar smoke cloud on Tuesday evening, members of the National Open Hearth Committee and the Blast Furnace, Coke Oven, and Raw Materials Committee were treated to refreshments prior to the beginning of the Annual Fellowship Dinner. But this dinner, unlike other conference dinners, was accompanied by the unusual . . . a real Bavarian band that played, among other things, many of the German drinking songs.

D. R. Loughrey took charge of post-dinner proceedings by presenting to M. F. Yarotsky, U. S. Steel Corp., a certificate of appreciation for his many years of faithful work with the NOHC. *McKune Award* Winner G. M. Hagenberger was presented with a certificate and a $200 check. The NOHC Conference Award was received by D. V. Roloff and E. V. Smith, Gary works, U. S. Steel Corp., for their paper, *A Study of Hot-Topping Practice*. J. W. Duncan presented a certificate of appreciation to F. M. Hamilton, Past Chairman, Blast Furnace, Coke Oven, and Raw Materials Committee for his many services to the Committee; he was also given a permanent registration card for future meetings. The JOURNAL OF METALS Award for the paper by Y. Doi and K. Kasai was received by Dr. Kasai, who had traveled from Japan for the occasion.

The meeting was the last before Assistant Convention Manager, James Ryan's retirement after 16 years service with AIME. Words and tokens of appreciation were lauded upon him from both committees participating in this convention as well as from C. E. Sims, representing the Electric Furnace Committee. Sentiments were expressed that *Jim* continue to serve these conventions in future years. A standing ovation was given as the well-liked figure of meeting rooms expressed thanks to "you bums."

Toastmaster-of-the-evening Joseph Holland, special assistant to the publisher, St. Louis Post-Dispatch, introduced AIME President Howard C. Pyle who spoke of the needs for member support of the new United Engineering Center. The evening's speaker, William McDonnell, president, US Chamber of Commerce and chairman of the board of the First National Bank in St. Louis, spoke of the dangers of inflation.

This serious note called for the return of the Bavarian band and the distribution of souvenir beer mugs, courtesy of the Southwestern NOHC section. They were soon put to good use, as waiters passed from table to table with foaming pitchers of Michelob, the beer that made the banquet famous.

Plant trips

Through the courtesy of Granite City Steel Co. and American Steel Foundries, plant visits were arranged for Wednesday, April 8th. At the latter, visitors were shown the open-hearth department with three 30-ton furnaces and the production-line foundry, largely devoted to the output of railroad car parts. The product development laboratory proved quite interesting, for there the firm carries on in-service testing of numerous parts, such as steel springs, and cast steel side-frames. New de-

The spirit of St. Louis, beer, and what goes with beer but a Bavarian band which played at the Annual Fellowship dinner. Below, left, J. W. Duncan, Chairman of the Blast furnace, Coke Oven, and Raw Materials Committee expresses thanks to retiring assistant convention manager, James Ryan. Below, right, G. M. Hagenberger, McKune Award Winner is presented with the certificate and prize by D. R. Loughrey on behalf of the National Open Hearth Committee. Pictures courtesy of Laclede Steel Co.

signs are evalulated in this laboratory prior to being put on a production basis.

Two tours were arranged at Granite City Steel Co.: one to the blast furnaces, sintering plant, and coke ovens, and the other to the open-hearths and strip rolling mills. Considerable interest was aroused by the use of oxygen in the open-hearth furnaces. All furnaces are fired with a mixture of 70 pct natural gas and 30 pct fuel oil atomized with steam. Two of the furnaces made use of oxygen lances inserted through the roof, with two lances being used in each case. One of these furnaces had an acid roof; the other had a roof of basic brick. One of the other open-hearths was being rebuilt; it will also have the two oxygen lances and an all-basic roof. At a later date a fourth furnace will make use of oxygen lances, but in this case two lances will be inserted from the end walls at the time of the melt-down and then gradually retracted.

The 42nd Conference of the National Open Hearth Steel Committee and the Blast Furnace, Coke Oven, and Raw Materials Committee ended following the plant visit and a noon meal served by the two host companies.

We left the old river port, as did many others, feeling that this was just about the best conference we had yet attended. Bouquets are in order for the "Globetrotter" Southwestern section of the National Open Hearth Steel Committee, which hosted the conferences.

METALS AND X-RAY EMISSION SPECTROGRAPHY

X-ray emission spectrography is currently enjoying a boom founded principally upon improved methods of X-ray detection. In a brief review, the main features of the method are sketched to show why it is of particular interest to metallurgists. Measurement of plating thickness, analysis of alloys, and point-to-point exploration of metallic specimens are described as typical metallurgical applications.

by Herman A. Liebhafsky

X-ray emission spectrography is the method of analysis that rests upon the identification of emitted X-ray lines and upon measurements of their intensities. These lines, the characteristic lines, can be excited by different agents, among which the most common are electrons and X-rays of shorter wave length. Characteristic lines produced in the latter way are known as *fluorescent*. This has caused X-ray emission spectrography with X-ray excitation to be called by various names that include *X-ray fluorescence* or some variant thereof.

The fundamental facts of atomic structure ensure that X-ray emission spectrography will make its best showing in the determination of metallic elements. The region of low atomic numbers, where the most important nonmetallic elements are found, is poorly suited to the practical application of this technique, owing to problems arising from the long wave lengths of the characteristic X-ray lines. As the atomic number increases, so does the proportion and relative importance of the metallic elements one encounters. In this larger region of the periodic table, X-ray emission spectrography is quite at home.

The need for analyzing metallic samples is always with us. Every analytical chemist knows how troubles multiply when samples contain metals of at least moderate atomic weights, for example, the rare earths, the platinum group, hafnium and zirconium, columbium and tantalum, tungsten, and uranium. Improved aids to separation, such as the use of new complexing agents, solvent extraction, and ion exchange resins, help a great deal, but there are few analytical chemists who would not welcome a satisfactory, broadly applicable physical method of analysis that has no need for separations. Optical emission spectrography, which can qualify as such a method for the lighter metals, has proved less valuable for the heavier, partly because the spectra for these are highly complex. X-ray emission spectrography escapes this objection because the X-ray spectra are comparatively simple at all atomic numbers.

Fig. 1 shows schematically how great is this simplicity. Suppose any atom of atomic number 29 (copper) or greater has incident upon it an X-ray beam sufficiently energetic to eject an electron from the K or L shell as shown. (Interaction of the beam with the nucleus will be neglected.) The filling of resultant vacancies by electrons from the outer shells gives rise to less than 20 characteristic X-ray lines (the K and L lines) of analytical interest. The maximum number of lines likely to be encountered during the analysis of a sample will not be many times greater.

The great simplicity of X-ray spectra is traceable ultimately to the fact that they generally originate deep within the atom. The electrons there are difficult to remove. The characteristic X-ray spectra consequently have high excitation energies. To cite an extreme example: the ejection of a K electron from uranium according to Fig. 1 requires energies corresponding to more than 110,000 v in the incident beam, which would have to contain wave lengths near 0.1 Å. These energies are actually beyond the reach of most laboratory equipment so that one usually prefers the L spectra for analytical purposes at high atomic numbers.

The properties of X-rays and their potential usefulness in analytical chemistry have long been known. To appreciate why, consider the close relationship of a Bragg spectrometer to an emission spectrograph with X-ray excitation. As Fig. 2 shows, we need add to the elements of a spectrometer (X-ray source, diffracting crystal, collimators, and detector) only a sample interposed ahead of the crystal in order to convert a spectrometer into a spectrograph.

1913, first experiments

The first indication that X-ray emission could be useful in chemical analysis came in an experiment carried out in 1913 by Moseley. He bombarded a brass target in an X-ray tube with electrons, and produced the characteristic lines of copper and of zinc by electron excitation. Upon analysis of the spectrum by Bragg reflection from a crystal, it turned out that the lines of copper were more intense than those of zinc. In this simple case, one was justified in concluding that the copper was present in the brass at a higher concentration than the zinc. In X-ray emission spectrography today, we are still interpreting line intensities in terms of

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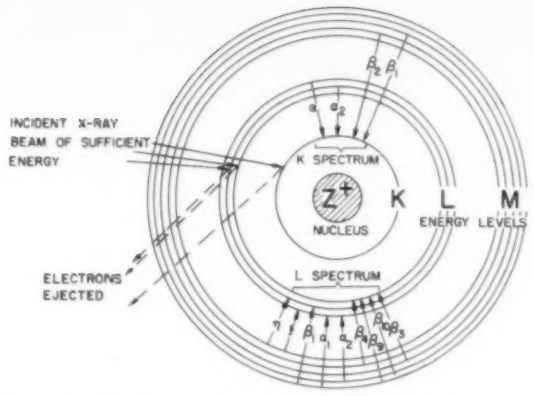

Fig. 1—Schematic diagram showing X-ray excitation of analytical X-ray lines for any element with at. no. 29 (copper) or greater. This same diagram will serve for electron or mixed excitation, if the incident beam is changed to consist of electrons, or of electrons and X-rays.

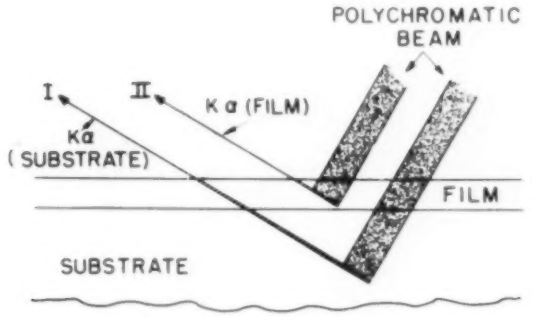

Fig. 3—Schematic diagram of two X-ray methods for determining film thickness.

concentrations, although X-ray excitation of the analytical lines has largely replaced electron excitation for various reasons, the great convenience and reliability of Coolidge (evacuated and sealed-off) X-ray tubes among them.

In spite of this promising start, Glockler, who did much to advance the use of X-rays, said in 1936 that X-ray emission spectrography would never displace the conventional wet methods of chemical analysis. Yet this displacement has begun, and it is accelerating. Why? For several reasons, but mainly because methods of X-ray detection have been enormously improved in the last 20 years. *X-ray detection* includes the measurement of X-ray intensity, which can now be done as a matter of routine with high precision in an analytical laboratory.

Moseley and those who followed him often had to photograph their spectra. The ionization chamber soon became prominent, but in its early form this detector was no more suited (though for different reasons) to routine X-ray emission spectrography than is the photographic plate. The X-ray intensities involved are often so low that it is necessary to count the individual quanta (one count for each quantum under simplest conditions). Nuclear physics has similar problems. The solution of these during the early years of the nuclear age made available for routine X-ray work three practical detectors in which the quanta are converted into pulses of electrons for counting: one quantum, one

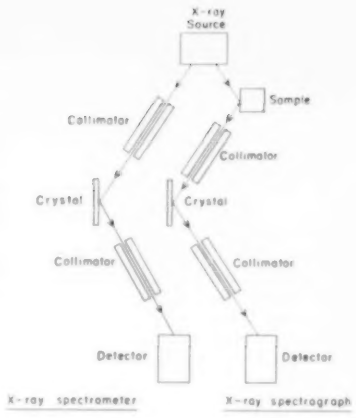

Fig. 2—Schematic diagram of an X-ray spectrometer and of an X-ray spectrograph. The spectrometer, left, is converted to a spectrograph, right, by the interposition of the sample between source and crystal.

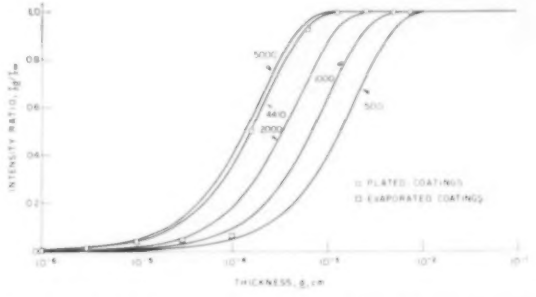

Fig. 4—Calculated curves showing relationship between intensity ratio and thickness for various values of a parameter that increases with the mass absorption coefficient.

pulse, one count—again under simplest conditions. The first such detector to become important in X-ray emission spectrography was the Geiger counter, in which the number of electrons in a pulse is independent of the energy (wave length) of the X-ray quantum. The Geiger counter is now yielding this field to the proportional and to the scintillation counter. In these last two counters, the number of electrons in a pulse is proportional to the energy of the X-ray quantum, or inversely proportional to its wave length. This proportionality is important because these two detectors can each be coupled to an electronic filter (pulse height selector, or pulse height discriminator) that makes it possible to increase the spectral purity of the X-ray beam leaving the sample, i.e., to increase the proportion of analytical-line quanta in the beam that reaches the detector.

With this necessarily incomplete introduction, let us examine representative ways in which X-ray emission spectrography can serve the metallurgist. In this examination, let us remember that the method is not only rapid, but non-destructive of the sample.

Determination of film thickness

The metallurgist is interested in a number of important problems for which the determination of tin-plate thickness on steel may serve as prototype. These problems differ from the ordinary thickness determinations, which resemble radiography, and in which a polychromatic X-ray beam (a beam of many wave lengths) passes through the sample and is attenuated. Thickness can be deduced from the degree of attenuation.

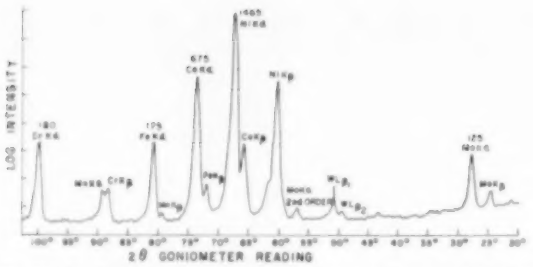

Fig. 5—Chart recording for high-temperature alloy resembling that of Table I. Numbers near the peaks are approx counts per sec for the five analytical lines of Table I. The ordinate is logarithm of counting rate. The abscissa is related to wavelength, as one may see from the wavelengths of the five analytical lines, which are: Cr $K\alpha$, 2.29 Å; Fe $K\alpha$, 1.94 Å; Co $K\alpha$, 1.79 Å; Ni $K\alpha$, 1.66 Å; Mo $K\alpha$, 0.71 Å.

Here we are concerned with problems of a different kind. A film (tin) rests upon a substrate (steel). We have two ways in which X-ray emission can be used to measure the thickness of the film[1,2,4,5], and these are diagrammed in Fig. 3.

In both ways (I and II), a polychromatic beam is incident upon the film. In I, this beam must penetrate to the substrate, where it excites characteristic lines. These lines (and scattered X-rays) pass through the film; the thicker the film, the more it attenuates (reduces the intensity of) the beam from the substrate. A detector properly positioned measures this attenuation. Similar measurements on known thicknesses (known, for example, through chemical analysis), yield a working curve from which unknown thicknesses can be deduced. In II, the polychromatic beam need excite characteristic lines only in the film itself. The intensities of these lines should vary with film thickness as shown in the calculated curves of Fig. 4. (For information about the experimental points of the figure, see Reference 5.)

Industrial installations for the control of film thickness according to I and according to II are successful. Up to now, the installations have been made principally on tin-plate lines, but extensions to other processes are likely. Also likely is a further step to more nearly complete automation in which an error signal from the X-ray gauge will be used to adjust the plating process in the proper direction.

Let us return briefly to Fig. 4. The ordinate is the ratio of the characteristic line from the film at thickness d to its ratio at *infinite thickness*. Clearly, infinite thickness is reached very soon, this being the point at which the ratio is unity. Why does this happen? Because both the polychromatic incident beam and the emergent characteristic line are attenuated, mainly owing to absorption by the film. The curves in Fig. 4 are for different absorption coefficients; the higher this coefficient, the sooner infinite thickness is reached. We call this an *absorption effect*, and it is important in analysis by X-ray emission spectrography. In Fig. 3, there is also a *filtering effect* on the incident polychromatic beam. Because longer-wave length X-rays are, in the main, more readily absorbed, these are *filtered* out of the beam so that its average wave length becomes shorter as it penetrates the sample.

Major constituents

Under the simplest conditions, the intensity of an analytical line is proportional to the number of atoms in the sample of the element characterized by the line. Such simple conditions obtain near the origin in Fig. 4, where the curves are linear. In most analyses, unfortunately, linear relationships do not exist, even if the spectrograph system is ideal. Deviations from linearity are caused by the absorption effects mentioned above, and filtering of the incident polychromatic beam may contribute when excitation is by X-rays. In addition, *enhancement effects* are often important. What then happens is that one element in a sample emits a characteristic line that is absorbed by the element being determined, with the result that the intensity of the analytical line is enhanced. These deviations are more serious with X-ray than with electron excitation. In addition, there are deviations attributable to heterogeneity when the samples are not homogeneous.

Nevertheless, the greatest immediate usefulness for X-ray emission spectrography seems to be in the routine determination of the major constituents of complex alloys. The deviations mentioned above simply make it necessary to carry out most analyses by comparing the unknown sample with a standard. When the range of compositions is narrow, and when standards in appropriate number are available, X-ray emission spectrography usually is to be preferred over conventional wet methods.

Before we turn to a modern example, let us see what was accomplished with electron excitation in the early days. Hadding[6] was the first to explore X-ray emission spectrography specifically as an analytical tool, and his first published data are for a metallic material—impure platinum. The results of Eddy and Laby[7] on a copper-zinc alloy are remarkable because of the high precision attained with a photographic plate as detector. To be sure, this case is among the most favorable that can be imagined. No calibration was required, and the percentage of only one element needed to be established. for the alloy was binary. The atomic numbers of copper and zinc are so near each other that the intensity ratio of their $K\alpha$ lines could, after an appropriate adjustment of experimental conditions, be assumed equal to the ratio of the number of atoms present of each metal. Because electron excitation was employed, absorption effects were at

Table I. Percentage Compositions Obtained by X-ray Emission Spectrography for Ten Samples from One Lot

Sample	Mo	Ni	Co	Fe	Cr	Total[a]
1	9.52	52.93	10.38	2.58	18.33	93.74
2	9.66	52.68	10.25	2.56	18.17	93.32
3	9.66	52.52	10.37	2.54	17.95	93.04
4	9.52	53.94	10.33	2.54	18.31	94.64
5	9.42	54.22	10.31	2.57	17.95	94.47
6	9.58	54.06	10.25	2.59	18.13	94.61
7	9.66	54.51	10.36	2.60	17.97	95.10
8	9.58	53.53	10.30	2.61	18.39	94.41
9	9.70	54.51	10.38	2.63	18.24	95.46
10	9.70	53.50	10.26	2.59	18.24	94.29
Mean[b] ($\overline{X}$)	9.60	53.64	10.32	2.58	18.17	94.31
s[c]	0.09	0.73	0.06	0.03	0.16	

[a] Approximate percentages of other elements present: C, 0.15; Ti, 2.5; Mn, 1.25; Si, 0.75; Al, 0.88.

[b] Composition of mean as given by X-ray emission spectrography assumed identical with composition as established by conventional chemical methods.

[c] Here, as elsewhere, the estimated standard deviation

$$s = \sqrt{\frac{\sum_i (X_i - \overline{X})^2}{n - 1}}$$

where X_i is the i'th individual value in a series of n determinations having $\overline{X}$ as mean.

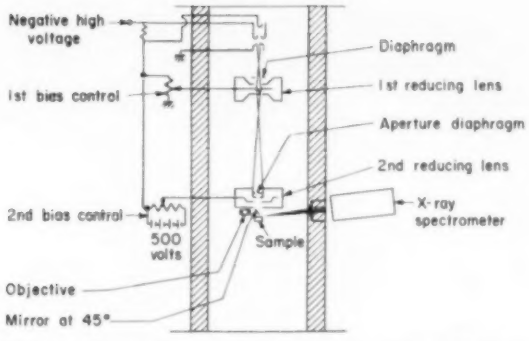

Fig. 6—Schematic diagram of original X-ray emission electron-microprobe (After Castaing and Guinier[14]).

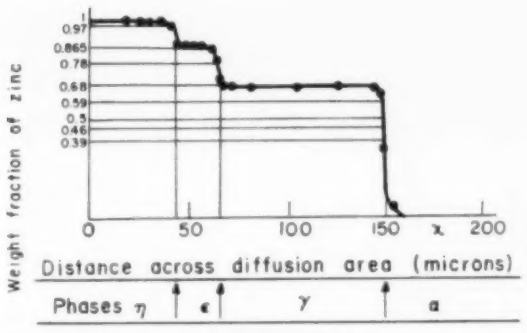

Fig. 7—Electron-microprobe analysis of a diffusion zone in a copper-zinc alloy (After Castaing and Guinier[14]).

a minimum. Under these simple conditions, compositions could be calculated satisfactorily from intensity ratios, as is shown by the following results for a series of 16 X-ray determinations on an alloy found by chemical methods (details not given) to contain 73.00 pct Cu: avg Cu content, 73.16 pct; standard deviation for a single determination, 0.27 pct Cu. There is no better practical illustration of advantages inherent in the simplicity of X-ray spectra.

By way of contrast, let us examine a more complex case in which X-ray excitation was employed and comparison of unknown to standard was mandatory. In fact, highly reliable results could be obtained only if standard and unknown approached identity in composition. The samples were high-temperature alloys, and the work was done by Brissey[8]. The chart recording (Fig. 5) shows roughly the alloy composition. The ordinate in the figure gives the logarithm of the intensities (intensities being measured by the number of counts registered by a Geiger counter over a fixed time) for the various characteristic lines whose wave length can be calculated from the goniometer setting plotted as abscissa. The satisfactory precision of the results is clear from Table I. They were obtained in less than one-twentieth of the time conventional wet methods required.

Trace determinations

In metallurgy, as in other sciences, the importance of traces is receiving increasing recognition, with increasing need for trace analyses as a result. Trace analysis, which is intended to include both qualitative and quantitative determinations, is conveniently subdivided into 1) traces as major constituents, a class in which the total sample is obviously minute and 2) traces as minor constituents in samples not unusually small. It is occasionally expedient to isolate the constituents of interest from a large sample so that they can be determined under simpler conditions; this amounts to shifting the determination from the second class to the first.

X-ray emission spectrography is proving surprisingly useful in trace analysis. As is true of the region near the origin of Fig. 4, the determination of traces as major constituents is often simplified because analytical-line intensity is proportional to amount present. Furthermore, calculations show that a spectrograph intended for routine work is capable of dealing with samples in the microgram range. Thus, it was estimated that the intensity of cobalt Kα generated under practicable conditions in a monolayer (area, 1 sq cm) of cobalt atoms might give 133 counts per sec. Such a sample weighs 0.2 μg. It would give higher counting rates in a spectrograph especially designed for trace determinations.

A chart recording of intensity was made in this laboratory by P. D. Zemany of the spectrum from a genuine bank note. Through the courtesy of the US Secret Service Office at Syracuse, N. Y., he was enabled to make similar recordings of the same region on a number of counterfeit bills of the same denomination. Each recording was characteristically different from the rest. A more convincing demonstration of the value of X-ray emission spectrography for qualitative trace analysis would be hard to find. In work such as this, the non-destructive character of the method is of particular value.

A major constituent trace determination, important in metallurgy, was carried out by Rhodin.[9] He studied films on stainless steels, mainly because such films largely determine the corrosion behavior of these alloys. The way in which Rhodin used X-ray emission spectrography is of great interest to analytical chemistry. He stripped these films from the alloys and supported them upon Mylar ($\frac{1}{4}$ mil thick) before determining their composition via X-ray emission spectrography. Films of metals were evaporated onto the same substrate to serve as standards. Outstanding quantitative results were obtained.

In the determination of traces as minor constituents, absorption and enhancement effects are likely to be important. One may, as Rhodin did, isolate the trace constituent so that it becomes a major part of the sample as placed in the spectrograph. The effects in question then tend to disappear. Or, if semi-quantitative results suffice, one may resort to estimated corrections of the peak heights, as was done with the bank notes, or one may make up a standard for comparison with the unknown. Suppose a heavy metal was present as a trace in a silicate-rock mineral. The mineral could be powdered and compared in the spectrograph either with a synthetic standard or with a known mineral of similar composition. X-ray emission spectrography is perhaps better adapted to semi-quantitative work of this kind than any other analytical technique. The extensive work in the Fluo-X-Spec Analytical Laboratory[10]—important to mining and hence to metallurgy—on the analysis of minerals has amply demonstrated this point.

The fact that characteristic-line intensities are largely independent of chemical state has not been mentioned because it is not particularly important

when metals or alloys are being analyzed. It can be extremely helpful in the analysis of minerals, as in the analysis of all samples containing chemical compounds.

Point-to-point exploration

Point-to-point exploration is important in metallurgical research. Exciting, either with X-rays or with electrons, the characteristic lines in volumes measured in cubic microns seems the best possible way of establishing highly localized composition. We shall discuss only electron excitation of characteristic lines on this scale, although the use of micro-focus X-ray tubes for this purpose[11, 12] is growing and has some distinct advantages.

In 1951, Castaing[13, 14] published results to show that an electron microscope could be converted into a useful X-ray emission spectrograph for point-to-point exploration on a micron scale. The conversion consisted mainly of adding a second electrostatic lens to obtain a narrower electron beam for the excitation of an X-ray spectrum, and of adding, externally, a spectrometer for analysis of the spectrum and measurement of analytical-line intensity. Outstanding features of the technique were the small size of sample (1 μ cube, or thereabouts) and the absence of pronounced absorption and enhancement effects, which of course is characteristic of electron excitation. For copper alloys, Castaing gives quantitative results that are remarkable in light of the scale of operations. The results in parentheses are the quotients I_λ/I_{Cu} (I_λ = intensity of Kα for copper in the alloy; I_{Cu} = corresponding intensity for pure copper) for alloys containing the following weight fractions of copper: 0.01 (0.0099); 0.04 (0.0373); 0.53 (0.504); 0.88 (0.867).

This kind of spectrograph system is complex enough to make naming it a problem. *X-ray emission electron-microprobe* has been chosen because it seems necessary to emphasize three salient features: it relies on X-ray emission and uses an electron beam as a *microprobe*.

Fig. 6 shows schematically the essential elements of such a microprobe. The four major components are:

1) Equipment for producing and controlling the electron beam;

2) The mechanism for moving the sample so as to accomplish scanning by the electron beam;

3) An optical system for examining the surface of the sample, and, most particularly, for locating the area under electron bombardment; and

4) Curved-crystal X-ray spectrometers as needed for spectrum analysis and intensity measurement.

Fig. 7 illustrates beautifully the usefulness of the microprobe for point-to-point exploration. Copper and zinc in contact were heated for 1 hr at 400°C to form a brassy diffusion zone about 0.1 mm wide, which was explored with the microprobe, the intensity of both zinc and copper lines being measured. The zinc results, as plotted in Fig. 7, show clearly the presence of the various phases predicted by the phase diagram with the single exception of the β phase, which escaped detection because (as subsequently established) it was only 1 μ wide. Furthermore, the copper results (not shown) were almost exactly as expected, i.e., at every distance along the abscissa the weight-fraction of copper plus that of zinc equalled unity.

For additional information about the X-ray emission electron-microprobe, the reader will do well to consult Birks and Brooks[15], who built a simplified probe that gave satisfactory results. They examined both metallic and non-metallic materials, the surface of the latter being covered by evaporation with about 50 A of manganese or copper to provide sufficient electrical conductivity.

The probes operating or being built in other laboratories are too numerous for listing here, but it seems worth mentioning that one has been constructed with the fine-focus electron optics of the General Electric X-ray Microscope as a basis.[16, 17]

The X-ray emission electron-microprobe is an elaborate and complex tool whose cost is justified when the information it yields is unique and sufficiently important. It is not an instrument that can be relied upon in unmodified form to give the average composition of large samples; the smallness of the electron beam makes it likely that a single analysis will not give average composition even in most samples thought to be uniform. But it is a tool that the metallurgist, concerned as he is with grain boundaries and inclusions, will find highly useful.

Conclusion

This brief review is necessarily incomplete. The improvement in methods for measuring relative X-ray intensity has rightfully been given major credit for the current and growing usefulness of X-ray emission spectrography, but other important improvements have been omitted. Yet X-ray tubes and X-ray spectrographs have been developed with reliable, rapid analyses in mind. The great success of the direct-reading spectrographs for the visible and ultraviolet in the metal industries[18] is providing a powerful impetus for the construction of similar X-ray equipment. We may look forward to the day when X-ray emission spectrography and emission spectrography at the longer wave lengths will each be assigned its proper share in the analysis of metals and alloys in the laboratory and on the production line. It seems safe to say that these two methods will complement each other and together dominate the determination of metallic elements.

The reader interested in exploring further the subject matter of this article will find references to the original literature in the *Analytical Chemistry* reviews, of which the latest appeared in 1958.[19]

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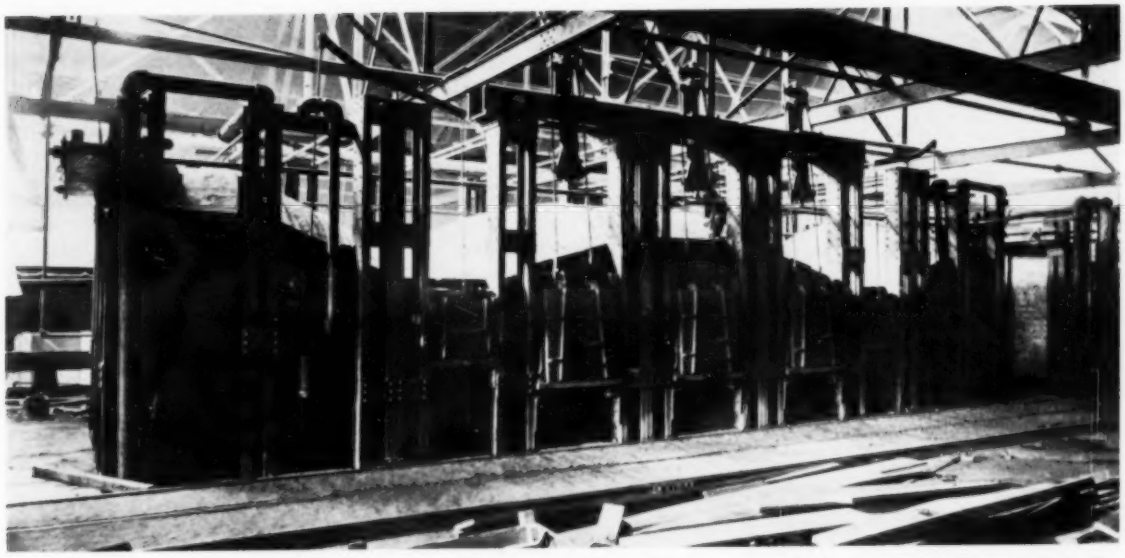

No. 7 furnace at the Cambria Open Hearth Shop, Cambria, Pa., about 1910.

STEELMAKING / U.S.A.

Part III of a four-part series on the history of steelmaking in the US, describes furnace developments, improvements during the last few decades, and the contribution of the AIME.

by Leo F. Reinartz

THE invention of the dolomite machine was a great boon to the open-hearth furnaceman. By speeding up bottom making, it helped to increase tons per hour and decrease cost. The first homemade unit was built and operated before 1925 at the South Side works of Jones & Laughlin Steel Corp., Pittsburgh. The first commercial machine, similar to those known today, was built for the Donner Steel Co., Buffalo, N. Y., in 1925.

Heavy slab buckstays, 6 in. by 15 in., supplanted lighter I-beam buckstays as furnace framework in the middle 1920's. They greatly improved the rigidity of the furnace binding.

Although the first sloping back wall had been installed prior to 1920 on a small basic open-hearth foundry furnace at Columbus, Ohio, the impetus to install such back walls universally in ingots shops came after S. Naismith installed the first one on an open-hearth furnace at Illinois Steel Company's South works in June 1924. Before that event, back-wall life had already been improved somewhat by the use of chrome rock or metal-encased basic brick.

Here again, these changes heralded major forward steps in furnace design, decreased costs, increased production, and improved safety and working conditions on the back standing of the furnace.

Fuels

Up to 1930, a number of different kinds of fuel were used to melt and refine steel in American open hearth furnaces. During World War I, powdered coal was used in a few plants as an open-hearth fuel, but because of the high sulfur and ash content in the coals, many operational difficulties arose. There were also dust, explosion, and accident hazards, so that after the War its use was discontinued.

In some steel-manufacturing centers, natural gas was available as a fuel and gave good performance.

In most steel-manufacturing centers, operators had to rely on producer gas made from bituminous coals in producer gas houses. Low-sulfur, low-ash, high-fusion coals required for the manufacture of such gas were not readily available. The quality of producer gas was uncertain. The gas had to be preheated. Maintenance problems connected with the use of this fuel were serious. Tons per hour per month was unsatisfactory.

Although petroleum had been first discovered by Edwin L. Drake at Titusville, Pa., in 1859, it was not until the early 1930's that heavy fuel oil residues for open-hearth use began to appear on the market. They were cheap; the calorific value was high, and it was not necessary to pass this fuel through the checkers to preheat it. Various plants began to use such oil as an open-hearth fuel. Others used it in combinations with tar, coke-oven, and/or blast-furnace gases. Because of its low calorific value, blast-furnace gas had to be preheated in the checkers.

These fuels were cleaner and more dependable than producer gas. The dirty gas house adjacent to the open-hearth shop was no longer needed, and

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with it went many serious personnel and maintenance problems.

Long, water-cooled ports, which were difficult to maintain, could be reduced in length or entirely eliminated. The hazard of an interchange of gas and air through uptake walls was gone. Hearths could be lengthened to increase their capacities 20 to 30 pct. Air and gas checkers could be used to preheat the incoming air for combustion. Larger heats and more tons per hour with lower fuel costs and less furnace maintenance were made possible by such changes. The morale of furnace personnel was improved.

While producer gas was used, furnace operations depended on the skill of the first helper. Earlier than 1915, fuel control was erratic. Roof life was low. End walls, downtakes, and checkers were overheated. Day-by-day quality, based on modern standards was not uniform. Furnace sealing and insulation were almost unknown. Tons per hour were low because of excessive brick repairs and other delays.

Furnace and ladle brick

Silica brick first appear to have been made out of quartz pebbles and Sharon conglomerate, with lime as a bond, at Akron, Ohio, in 1866.

Since 1926, many improvements in the manufacture of silica brick have been made. Brick have been powder dry-ground instead of in a wet pan; powder-pressed dry; grains pre-sized; tunnel-kiln fired. All these operations are now under close chemical, physical, and temperature control. In 1940, low-alumina, superduty silica brick were put on the market. They contain less than 0.5 pct alumina, titania, and alkalies.

Present day silica roof brick have enough strength to withstand arch stresses and, at the same time, can withstand the corrosive action of basic dust and iron oxide fumes as well as high temperatures. The rib-type construction has been adopted almost universally. Roofs are thicker near the skewback channels than in the center of the furnace.

The first magnesite brick were made in 1895 by the Fayette Mfg. Co., Layton, Pa., using Austrian and Grecian magnesites.

The first chrome brick were made by the same company in 1896. At first, they were used as a neutral zone between silica walls and the basic banks in furnace hearths. In 1913, at the Phoenix Iron Works, Pheonixville, Pa., N. E. McCallum first installed magnesite brick in a back wall. Steel plates were used between the rows to help hold the brick in place when heated to furnace temperatures. Later on, magnesite was rammed into short boiler tubes. These were then used in back-wall and end-wall construction.

The first unfired basic brick were manufactured in 1923. Such brick contained about 65 pct magnesite and 35 pct chrome ore bonded with a little silicate of soda. Later, improvements in brick manufacture were made by better selection of raw materials, better grain sizing, use of metal containers, and so forth. These were the forerunners of the modern Metal-kase basic brick, which are often used whereever extreme heat and corrosion occur in the furnace.

Main basic roofs, arched or flat, have not advance as far as basic-end, back-wall, and front-wall construction. Basic roofs must be suspended from special hangers. Brick must be held together by tie rods and powerful tangential springs at front and rear skewbacks in order to equalize stresses in all parts of the roof. To prevent spalling, basic roof brick must be kept at as high a temperature as possible, preferably up to 2900°F. This is especially essential during bottom making.

The all-basic furnace allows improved combustion. Oxygen can be used with fuel for combustion. High fuel input throughout the complete melting cycle may be maintained. Preheat temperatures are high. Monthly ingot tonnage is high because of increased furnace availability and tons per hour.

Checker chamber roofs on new furnaces and on many modernized furnaces are flat and brick are suspended. High heat-withstanding, fireclay, superduty brick are used in such construction.

High-quality fireclay brick continue to be used for most checker chamber installations because they are highly refractory, have volume stability and resist spalling. Where firing rates have been stepped up in modern furnaces, high-alumina fireclay brick or basic brick have been installed in the top 8 to 12 courses of checker chambers, to resist temperature and dust slagging action. To date, their economy has not been universally acknowledged.

Ladle brick usually are not as refractory as furnace brick. They must resist spalling when sudden heat is applied and swell enough to close cracks between the bricks. In recent years, much has been accomplished by the manufacturers to improve the quality of ladle, sleeve, and nozzle brick. Stoppers continue to be made out of graphitized fireclay. More refractory materials are used only when extreme cleanliness is required, for example, in the manufacture of high-grade alloy steels.

Instrument control

Instrument control prior to World War I was limited to a few steam gages and other gages. In those days, fuel consumption in hot-metal shops was often more than 6 million Btu per ton. In cold-metal shops, this figure went up almost to 10 million Btu.

As time went on, instrument control increased and gradually improved. Furnace crews received better training in combustion and furnace control. Fuel systems were more flexible and adaptable. Furnaces were sealed and insulated. Year by year, the fuel consumption in open-hearth furnaces has come down. Today in modern shops using 50 pct or more hot-metal in the charge, it is a common occurrence to record the use of less than 3 million Btu to melt and refine steel. Progressive cold-metal shops can boast of less than 4.5 million Btu per ton.

National Open Hearth Committee

During the year 1925, an unheralded event took place in Pittsburgh. The American Institute of Mining Engineers, known as AIME, had been organized as a mining society in 1871. In 1919, the metallurgists joined this society and the name became American Institute of Mining and Metallurgical Engineers (but still AIME). An important part of the latter's activities was connected with the technical phases of iron and steel manufacture.

Organization

J. V. W. Reynders, a prominent consulting engineer, bridge builder, and a former vice presi-

dent of Bethlehem Steel Co., was the President of AIME in 1925. He had an idea that open-hearth operators and metallurgists of smaller, independent steel companies would profit by meeting and discussing operating, maintenance, and quality problems in the same manner as had been done for many years by the Bethlehem and U. S. Steel Corporations.

He invited the presidents of independent steel companies to send representatives to Pittsburgh to determine whether a similar group could be formed. Twenty-six operators and metallurgists met in the William Penn Hotel in May 1925, to discuss this subject. They endorsed Mr. Reynders' proposal enthusiastically and immediately organized a practice committee which, in short time, became the National Open Hearth Committee of the AIME. Since then, national conferences have been held each year.

Growth

Some time after this committee began to function the Blast Furnace and Raw Materials Committee of the AIME accepted an invitation to join forces with the National Open Hearth Committee in the annual Conference, to the mutual benefit of the two groups.

Over a period of years begining in 1936, ten regional sections of NOHC have been organized. All are active. Each holds one or more technical and social meetings each year. The attendance at annual conferences has topped 1800. (attendance in 1959 was 1560) Regional meetings draw an additional 4000.

Effect of Conferences

The papers and discussions presented at the national meetings, as well as the informal discussions between sessions in the hallways and in the hotel rooms, have been valuable to individuals as well as to the companies they represent.

Through the years these conferences have mirrored, spark-plugged, and recorded the advances in the art of steelmaking. In fact, during the restricted travel days of World War II, the national committees were permitted to hold meetings because government officials believed their discussions were important for the war effort.

The yearly Proceedings of the national conferences have chronicled the improvements made in the steel industry, and also have recorded the results of experiments that did not turn out so well. They have become the repository of most of the accumulated knowledge and practices of basic steelmaking in the United States since 1925. Scientists, metallurgists, suppliers, and operators, young, and old, meet on an equal footing in these conferences to discuss their mutual problems. Throughout these years many lasting friendships have been formed.

Perhaps the passage of years mellows our memory so that we look back with nostalgic remembrance on the events of long ago. It is true, nevertheless, that many colorful and interesting men took part in the early deliberations of the National Open Hearth Conferences. Most of them had come up through the school of hard knocks as furnace helpers, melters, and superintendents. The names of only a few can be cited, as the list is long. The majority have either retired or gone to their reward but they have left behind the imprint of their forceful personalities:

Operators: "Major" T. W. Mills, Granite City Steel Co., T. T. Scott, Sr., Sheffield Steel Co., L. E. Yost, Corrigan-McKinney Steel Co., John Gething, Laclede Steel Co., E. L. (Buck) Ramsay, Wisconsin Steel Co., William Kitto, Pittsburgh Steel Co., F. A. King, Weirton Steel Co., R. L. Levantry, Republic Steel Corp., S. B. Muir, Donner Steel Co., Clem Collinswood, Stanley Works, W. A. Maxwell, Inland Steel Co., A. W. Smith, Youngstown Sheet & Tube Co., Jerry Walters, Lukens Steel Co., J. M. Hughes, Sharon Steel Hoop Co., H. B. Hubbard, Inland Steel Co., A. R Maxwell, Pittsburgh Steel Co., E. A. Whitworth, Boure-Fuller Co., F. B. McKune, Steel Company of Canada, J. R. Mountain, Trumbull Steel Co., H. A. Young, Allegheny Steel Co., J. H. McElhinney, Lukens Steel Co., K. C. McCutcheon, Armco Steel Corp., G. D. Cain, Republic Iron & Steel Co., Marion Crabtree, American Steel Foundries, G. D. Tranter, American Rolling Mill Co., K. V. McCausland, Wickwire Spencer Steel Corp., T. J. Costello Follansbee Company.

Metallurgists, combustion men, and others: Dr. C. H. Herty, Jr., US Bureau of Mines, Prof. W. J. McCaughey, Ohio State University, H. V. Flagg, American Rolling Mill Co., F. E. Leahy, Youngstown Sheet & Tube Co., J. N. Nead, American Rolling Mill Co., W. J. Fleming, Andrews Steel Co., L. B. Lindemuth, Lindemuth & Carney Co.

No attempt has been made to cite the names of all those who are still active in the steel industry. It is interesting to note how many company names in this list have disappeared or have been swallowed up by mergers and other combinations.

Suffice to say that the National Open Hearth Steel Committee of AIME owes a great debt of gratitude to those, living and dead, who helped to lay the foundation of this great movement.

(Mr. Reinartz is too modest to mention his own contributions. He was foremost in the work of forming the Committee and served as its Chairman for 18 years (from 1927 to 1945).—Ed.)

Advances in industry recorded

Improvements made in open-hearth design and practice prior to 1925 have already been cited. The records of the Open Hearth Committee between 1925 and 1945 show the installation of chrome-ore subhearths; rammed basic bottoms, sealing and insulation of furnaces below floor level, the introduction of rigid binding with large slab buckstays, improved instrumentation and furnace controls, better mold design, improved ladle refractories, vertical stopper-rod ovens and better pit practices, oval all-welded ladles, improved refractories (silica, fireclay, and basic brick), the use of powerful diesel locomotives, improved auxiliaries, and many other items.

In the control and improvement of quality, discussions have been held with reference to residual nonferrous metals in scrap iron; effect of hot-metal temperatures and analyses; effect of iron oxide in slag and metal; methods of preventing segregation, inclusions, and excess gases; use of mechanical aids such as viscosimeters, slag cakes, pyrometers to improve slag and metal control, and other control methods; manufacture of hot-topped and deep-drawing steels.

Discussions with reference to quality were usually led by Dr. Charles H. Herty, Jr. Because of his brilliant, practical efforts and those of a number of other young metallurgists, open-hearth superinten-

dents and furnacemen gained a nontechnical insight into the quality requirements of modern steel users and a greater appreciation of their needs. They learned how to improve quality by slag and metal temperature as well as combustion and analysis control, together with careful furnace manipulations.

This knowledge was put to excellent use during World War II, when demand for specialty open-hearth steels increased by leaps and bounds, which necessarily led to an unprecedented increase in open-hearth production during war days.

Upward spiral in steel industry

After a slight pause in building new capacity following the end of the war, by 1950 this upward spiral began again at a rapid pace. The consumption of steel per capita increased from about 300 lb in 1900 to almost 1400 lb in 1957. Ingot capacity figures released by the American Iron and Steel Institute record a total US steelmaking capacity of 147,633,670 net tons as of Jan. 1, 1959, of which more than 87 pct is basic open-hearth steel.

The unprecedented postwar demand for steel had many causes. Some of them were: 1) the need to catch up on restricted civilian requirements caused by the war, 2) the urgent need for rehabilitation of devastated Europe, 3) the public's increased demand for the products of industry: automobiles and trucks, airplanes, steel pipelines, transportation, home and office appliances, highways, air conditioning, steel buildings, and many others—the marvel and envy of all the other peoples of the world, 4) the new technology: radios, television, electronics, nuclear fission, jet planes, rockets, and guided missiles, plus the breathtaking predictions for space conquest, 5) the Korean War interlude with the public's demand for "butter and bullets", 6) the phenomenal increase in chemical, petroleum, and related industries, 7) the increased crop of new citizens, 8) fewer hours of work, leaving more time for leisure, do-it-yourself jobs, moon-lighting, and recreation.

Notable advances

During the past 10 years, notable advances have been made in open-hearth furnace design and operation which have increased production, improved quality, and reduced costs. Only a few can be listed here.

1. Furnace hearths are being widened and lengthened. Roofs have been raised. Basic front and back walls are universally installed. Extensive experiments are going on in many plants using all-basic ends, baic roofs, and checkers capped with basic or high-alumina brick, permitting more heat units per hour from the fuel burned, especially during charging and melting periods.

2. Charging pans have been enlarged, some up to 75 cu ft capacity. Open-hearth doors have been necessarily enlarged. Scrap iron is prepared so that in many intergrated hot-metal shops charging time does not exceed 1 to 1½ hr. In one plant, scrap is being brought to the charging floor by means of elevators, one buggy at a time. Each furnace is a unit by itself. Floor delays have been greatly reduced and tons per hour of furnace increased.

Another plant is testing a new device that does away with many charging cars and pans on the charging floor. Scrap iron is charged by means of a magnet directly from 50-ton cars into a chute in front of the furnace. The scrap iron drops through the chute into a charging pan on one car and is quickly charged into the furnace.

3. Combustion control has received much attention; flame velocities have been increased, thus more Btu are burned per hour. Large furnaces using some oxygen have approached a production of 50 tons per hour. A number of shops use high-pressure natural gas to atomize fuel oil in open-hearth furnaces.

4. A new phenomenon is the increasing use of low-cost oxygen tonnage in open-hearth shops for maintenance, combustion, and carbon reduction.

5. Over a period of years, heat sizes in some plants have increased beyond ladle crane, runway, and ladle capacities. These larger heats, therefore, are being tapped through bifurcated spouts into two ladles. Increases of 20 to 40 pct in tons per hour, depending on furnace size, use of oxygen, and local conditions, have been reported.

6. Use of jet tappers and autopour devices has increased reliability and safety in handling molten metal in open-hearth pit operations.

In addition, a number of other outstanding developments in recent years might be cited:

1. Improved methods of repairing and rebuilding open-hearth furnaces in record time by the use of bulldozers and traxcavators, elevators, machines to remove roof brick from furnaces, air washers and fans to cool open-hearth floor and furnaces, during repair times, gravity and power conveyors, metal centers for roof installations, powerful explosives, and others.

2. The incorporation in new furnace designs of large single-uptake slag pockets, suspended chill walls, fantail roofs and noses: suspended flat checker chamber roofs; two-pass and three-pass checkers, and soot blowers.

3. Redesigned fuel burners for higher heat input per hour and use of oxygen for combustion.

4. Improved furnace refractories and the development of an efficient gun with which to patch furnace interiors.

5. Automatic reversal of valves, large fans for sufficient combustion air, and adequate draft.

6. Increased use of instrumentation: air:fuel ratio control, roof and checker temperature control; indicating and recording meters for steam, fuel, air; immersion couples, telautographs, high-temperature optical pyrometers.

7. Improvement in hot-topping big-end-up ingots for quality improvement in forging and alloy steels.

8. Improvement in the manufacture of deep-drawing, non-aging steels for automobile manufacture, and oriented silicon steel for transformer and other electrical uses.

9. Standardization of all phases of operations and metallurgical control.

10. A greater appreciation of the value of good maintenance, training, and safety in open-hearth operations.

These are only some of the methods and equipment used in modern open-hearth shops to bring this process to its high state of perfection. Improvements will continue to be made in the future as in the past because of the intelligent work of all those who have anything to do with steel manufacture.

(Next month: electric steel, LD process, steel companies, men of vision, and predictions.)

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METALLURGICAL SOCIETY OF AIME

NEWS

Stress Corrosion Conference Brings Strange Bedfellows Together At Pittsburgh

Take a chemist, a solid-state physicist, and a metallurgist, mix well and leave them alone for a day or two. In the end, they would very likely be discussing the problem of stress corrosion fracture. (An observor would note that such a mixture is decidedly exothermic in nature.)

Such a situation existed, on a much enlarged scale, at the technical conference on the Physical Metallurgy of Stress Corrosion Fracture, held during the first week in April at the Mellon Institute in Pittsburgh.

More than 225 persons attended the conference, sponsored by the Corrosion Resistant Metals Committee of the Institute of Metals Div. and the Pittsburgh section of AIME. The meeting was held in cooperation with the American Society of Testing Materials, the Electrochemical Society, and the National Association of Corrosion Engineers.

The process of stress corrosion cracking represents the final product of a complicated sequence of chemical, electrochemical, and mechanical-physical reactions. It is one of the most frustrating and serious forms of corrosion failure that modern engineering materials exhibit.

It was this problem that registrants at the conference approached, and discussion was lively and interesting. That no "final" solution was achieved is not surprising. Improved definition of the process was obtained, however, in terms of physical, electrochemical, and metallurgical characteristics. New ideas, data, and techniques were reported and discussed by specialists in the fields of engineering and the solid-state sciences.

Complete proceedings of the conference, including discussions, are to be published in a hard-cover edition. Thor N. Rhodin, Cornell University, will edit the volume. Interested readers are advised to watch for announcement of publication in JOURNAL OF METALS.

A special grant from the National Science Foundation enabled several scientists from abroad to attend the meeting, all of whom are renown in the field of stress corrosion.

The group included: C. Edeleanu, Tube Investments Ltd., H. J. Engell, Max Planck Institut für Eisenforschung, and P. G. Bastien, Société des Forges et Ateliers du Creusot. A. J. Forty, Bristol University, participated indirectly but was unable to attend.

Mr. Rodin, Chairman of the Corrosion Resistant Metals Committee, served as conference chairman. W. R. Bitler, Carnegie Institute of Technology, handled conference arrangements.

Metallurgical Society To Host British ISI

The Metallurgical Society of AIME will serve as host to The Iron and Steel Institute, of London, at its Fall meeting in 1961.

Acceptance of an invitation from The Metallurgical Society was confirmed at the Institute's annual general meeting, May 6.

The I.S.I. President, C. R. Wheeler, read his acceptance notice at that meeting, and gained the official sanction of the membership at large.

The announcement read in part: "The Council has given a good deal of thought to the possibility of holding a meeting in the United States of America. We are all agreed that it is most desirable from many points of view that we should have a meeting there. Accordingly, it is with very real pleasure that I can tell you that an invitation has been re-

(Continued on page 408)

Plan Semiconductor Conference at Boston

Detailed planning is almost completed for the Conference on Properties of Elemental and Compound Semiconductors, to be held at the Statler Hotel in Boston, Aug. 31 to Sept. 2, 1959.

Four sessions of invited and contributed papers have been organized for the meeting, which will also feature a visit to MIT's Lincoln Laboratories.

The conference is being jointly sponsored by the IMD Semiconductors Committee of The Metallurgical Society, and the Boston section of AIME. The complete program for the meeting will appear in the July JOURNAL OF METALS.

The Conference is designed to provide a review of properties of all types of semiconductors. Reports will also be made on new developments of interest to those working in the field of semiconductor metallurgy.

Ample opportunities for informal gatherings and exchange of ideas will be provided during the conference, and a social hour and dinner is planned for Monday evening, August 31.

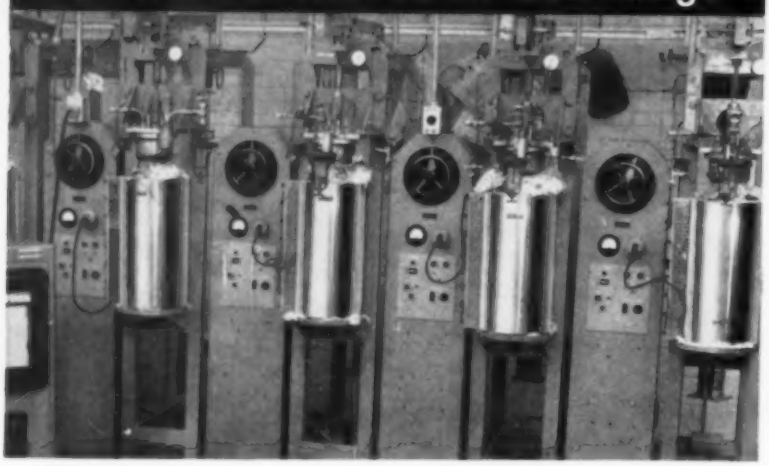
The tentative program for the Conference will be mailed to all members of the Institute of Metals Div. this month. Others interested in the program may obtain copies from the Conference Chairman, W. C. Hittinger, Bell Telephone Laboratories, 555 Union Blvd., Allentown, Pa.

Registration fee for AIME members is $10; for non-members, $15. Payment of this fee entitles registrants to a copy of the Conference Proceedings, which will include both papers and discussion.

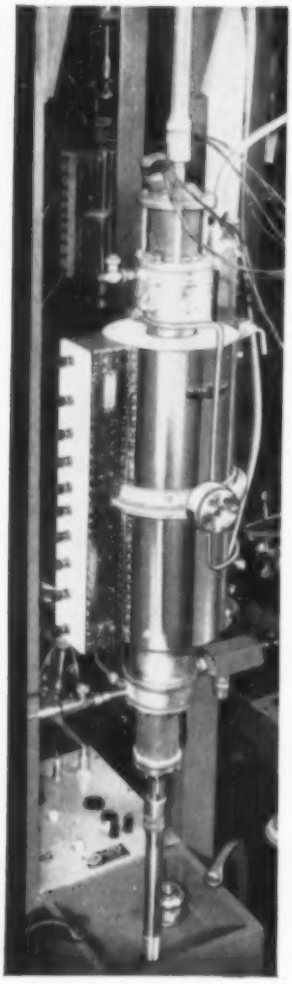
D. C. Jillson of General Electric Co; Fred Rosi of RCA; and Baldwin Sawyer, and J. H. Scaff of Bell Telephone Laboratories are assisting in the Semiconductors Committee's planning.

The Local Arrangements Committee of the Boston section is headed by Prof. T. B. King, MIT.

Marshall Furnaces at Oak Ridge



1000 to 1800° F ± 1.5°



At Oak Ridge, Marshall furnaces accurately maintain set temperature levels in the range of 1000 to 1800° F., within ± 1.5° F. The furnaces are vital components of specially designed and built gaseous and vacuum creep rigs. Creep properties of structural metals are tested under the effect of high temperature gases, vacuum, various liquids, and liquid metals. The rigs were developed by the Oak Ridge National Laboratory, operated by Union Carbide Corporation for the U. S. Atomic Energy Commission, and the furnaces were built to their specifications by Marshall Products Co. After more than four years of virtually continuous service, all major components are still in operation!

This accuracy and dependability is typical of Marshall furnaces used widely as components of machines for creep testing metallic alloys, and also for tensile, stress-rupture, and fatigue testing of metals, ceramics and cermets.

Marshall offers a range of standard tubular, shunt-type furnaces compactly designed to apply electrical heat *up to 2600° F*, under exact control. Units feature *uniform temperature distribution* and *rigid zone control to ± 3° F* at any point in the test zone. Under certain conditions operators report temperatures can be held to ± 1° F. Test durations may range from moments to 10,000 or more hours.

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Liquid-metal creep testing frames (shown at top)
Creep testing in various gaseous environments (left)

ISI Joint Meeting

(Continued from page 407)

ceived from the Metallurgical Society of AIME. . . The Secretary wrote on Mar. 31, 1959:

'As directed by the Board of Directors of The Metallurgical Society of AIME, I have been authorized to extend to The Iron and Steel Institute a cordial invitation to hold a Joint Meeting with our organization in the fall of 1961. We sincerely hope that this invitation will meet with acceptance by the Council of The Iron and Steel Institute.' . . .

"I am sure that you will wish to join with me in expressing appreciation to The Metallurgical Society of AIME for their initiative in issuing their cordial invitation."

In the months ahead, detailed plans for the meeting will be developed. John Chipman, President of The Metallurgical Society, has appointed James B. Austin, Administrative Vice President, Research and Development, U. S. Steel Corp., to head a planning committee.

EJC Backs Govt.-Level Engineering Branch

Creation of a US Cabinet-level Department of Science and Engineering was solidly backed by the Engineers Joint Council, in a statement before the Subcommittee on Reorganization and International Organizations of the Senate Committee on Government Operations, April 16th.

EJC was represented at the hearing by Enoch R. Needles, President, and Augustus B. Kinzel, Past President of the AIME, currently Vice President of EJC.

Such a new department should "bring together the activities of a broad engineering and scientific nature not directly pertinent to the missions of other departments," President Needles explained. "In addition, it should co-ordinate science and engineering in such departments by some device such as The Federal Council for Science and Technology, recently established in order to insure the development of balanced programs, prevent dissipation of efforts, and insure the preservation of our excellence in the fundamental areas of science and engineering.

Mr. Needles statement also deplored the indiscriminate use of the word *technology* as a substitute for *engineering*.

We strongly urge that any administrative development in this field be properly identified as *Science and Engineering*, not only as a matter of recognition, but also as a matter of clearly setting forth the intent of the measures to include the field of engineering activities.

Engineer Economist Begins Publication

A new quarterly journal, *The Engineering Economist*, is beginning publication under the sponsorship of the engineering economy division of the American Society for Engineering Education. The journal presents the latest developments in engineering economics, equipment acquisition and replacement analysis, capital budgeting, economic evaluation, and related subjects.

Subscription rate is $3 per year in the US and Canada; $4 elsewhere. Checks may be made payable to The Engineering Economist; *Box L, Stevens Institute of Technology, Hoboken, N. J.*

ASTM Holds Annual Meeting in Atlantic City on June 21-26

Education of the engineer in the materials sciences, the use of isotopes in metals analysis and testing, basic research, and an open forum on standardization of materials for nuclear reactors will be features of the 62nd Annual Meeting of the American Society for Testing Materials at Chalfonte-Haddon Hall, Atlantic City, N. J., from June 21st to 26th.

Sessions on fatigue, effect of temperature, steel, spectroscopic excitation sources, microscopy, identification of water-formed deposits, and visual aids for standardizing and communicating product appearance will round out a program of 36 technical and report sessions.

AIME Member Heads French Metallurgy Soc.

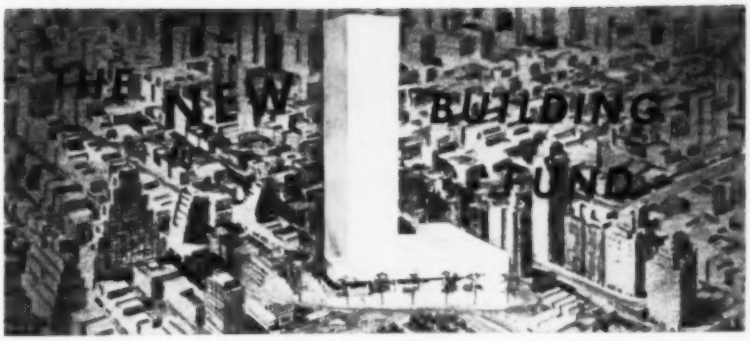
Paul G. Bastien, member of the AIME since 1946, is the 1959 president of the Société Francaise de Metallurgie.

Mr. Bastien, who is with the Société des Forges et Ateliers du Creusot, in Paris, recently spoke on *Physical Metallurgy of Stress Corrosion Fracture* at the Stress Corrosion Fracture conference in Pittsburgh.

In other elections, Max Dupont, AIME member since 1955, was named Secretary General of the Society. Andre Sourdillon was elected to the newly-created office of General Delegate in charge of foreign relations.

CORRECTION

The May issue of JOURNAL OF METALS incorrectly stated that the name of *Endowment Fund "X"* was changed to *The Henry Krumb Memorial Fund*. The new name selected for the fund is *The Henry Krumb Endowment Fund*.



WITH the Building Fund Campaign for the proposed United Engineering Center drawing into its final stages, only 53 pct, or $263,671 of AIME's $500,000 goal has been achieved.

Progress toward the total building fund goal of $8 million has fared better, however.

Of the $3 million quota set for the entire membership of engineering societies, $2,321,920 had been pledged by May 1. Industry's $5 million goal is being approached more rapidly, with $4,311,983 collected thus far.

AIME's aim for $500,000, meanwhile, is falling short at this writing. The organization has dropped from its front-running position among engineering societies, in Aug. 1958, to last place at this date.

ASCE, conversely, has pledged 60 pct of its $800,000 quota; ASME, 62 pct of $800,000; AIEE, 83 pct of $900,000; and AIChE, 97 pct of $300,000.

Some local sections of AIME, however, have met and even exceeded their goals. At least 10 chapters have exceeded their quotas at this writing, while 11 others have gained 50 pct or more.

"Some local sections got an early start," according to Edward H. Robie, Acting Secretary for the AIME Members' Gifts Campaign. "And, with good organization, achieved their goals without difficulty, though with some earnest canvassing.

"Perhaps the most difficult job was assigned to the New York section," says Mr. Robie." The large membership in the metropolitan area of New York, New Jersey, and nearby Connecticut made the appointment of canvassers and their job of reaching individual members a formidable one.

"But because the new building is to be erected in New York and local pride is involved . . . . the New York section was given a goal of $200,000, with the remaining sections total set for $300,000."

The site for the new building extends from 47th to 48th St. on First Ave. facing the United Nations Plaza in New York City.

When completed, the building will be 18 stories high, and contain nearly 250,000 sq ft of floor space to accommodate the engineering societies administrative offices, publication facilities, meeting and conference rooms, displays and exhibits, and other offices.

Occupancy is scheduled for 1961, with a tentative working schedule for construction just having been released by the board of trustees in charge of the United Engineering Center project. The schedule is as follows:

Aug. 30, 1959—Completion of working drawings
Sept. 30, 1959—Confirmation of guaranteed limit of cost
Oct. 15, 1959—Commencement of construction
Mar. 15, 1961—Completion of construction
July 1, 1961—Completion of occupants' requirements for occupany

"Adoption of this construction schedule gives a sense of urgency to the attainment of the subscription quotas in the Industrial and Member Gifts Campaigns at the earliest possible date," the United Engineering Trustees, Inc., explains.

AIME members are reminded that pledges may be paid over a three-year period, and may be paid either in cash or in securities, if the latter type payment is more favorable to the member.

Engineer Building Fund Gains with Assistance From Local Sections

Ohio Valley section of the AIME is the first of the predominantly metals sections to reach its assigned quota in the member gifts campaign for the United Engineering Center Building Fund. By the middle of March, 108 of the 432 section members had pledged a total of $6491, or 135 pct of their $4800 goal. Nine sections of the Institute have reached their quotas, some almost three times over.

The Ohio Valley section, centering in Columbus, has 269 members in The Metallurgical Society, 126 members in The Society of Mining Engineers, and 30 members in The Society of Petroleum Engineers.

AROUND THE SECTIONS

San Francisco section was presented with a film and narration by R. K. Johnson, Western-Knapp Engineering Co. at their April 8th meeting. The film, *WKE Builds for the Future*, was the story of Kennecott Copper Company's new smelter at Hayden, Ariz. Mr. Johnson played an active role in the design and construction of the smelter.

El Paso section also entertained Mr. Johnson (see San Francisco) and heard about the Kennecott smelter on March 11th at the Hotel Cortez. The April 16th meeting was held jointly with the Kidd Mining Club at Texas Western College. A bean feed shared the limelight. El Paso's spring dinner-dance was held at the Del Camino Cafe on May 16th.

San Francisco section heard E. W. O'Rorke speak on the *Future of Atomic Power and the Use of Nuclear Fuel* at its dinner meeting May 13th.

Mr. O'Rorke, Mgr. of Fuels and Materials Engineering, Atomic Products Equipment Dept., General Electric Co., San Jose, has been active in atomic energy work since the early '40s.

His talk included a description of current and future boiling water reactor development, and suggested a method of producing nuclear power economically. He also outlined current and anticipated research development in nuclear fuels.

Adirondack section's schedule shows a busy summer for members beginning on **June 27th** with a visit to the Cabot Carbon Co., Cabot Minerals div., Willsboro. If there is sufficient interest in the mine and mill operations, a symposium on maintenance will be organized prior to the meeting. On **July 25th** a trip to the St. Lawrence Seaway and Power project will be made. Close inspection of the plant and equipment are expected. Trips to either National Lead's pigment plant at Varennes, Quebec, or the Quebec Iron and Titanium of Sorel are being arranged for **August 29th.** Depending upon arrangements, it may be possible to see both points of interest and spend a weekend in Montreal. Wives are invited on this jaunt. Wives are also invited on the **September 26th** journey to the Vermont Asbestos operations at Hyde Park, Vt. The host is interested in a fairly definite idea of how many members will make this trip.

Southeast section held its Spring meeting at the Holston Hills Country Club, Knoxville, Tenn., May 8th. Highlight of the meeting was a talk on mining operations at Ore Knob, N. C., by Phillip Eckman, of Appalachian Sulphides Inc.

An annual picnic, scheduled for Aug. 15th, is next on the Section's agenda.

Looking ahead still further, a two-day Fall meeting at the Riverside Hotel, Gatlinburg, Tenn., is planned. The Sept. 25-26 meeting will also feature a field trip.

Rounding out the calendar will be the Section's annual Christmas party, slated for the C'est Bon Restaurant in Knoxville, Dec. 5th.

St. Louis section was taken on *A Visit To Russia* by W. R. Hibbard, Jr., vice president of the AIME, and General Electric researcher, at its Annual Dinner-Dance, in St. Louis, May 8th. Dr. Hibbard, Manager of the Alloy Studies Section, Metallurgy and Ceramics Dept. of G. E. Research Laboratory, recounted his experience as a member of an 11-man US delegation that toured the Soviet Union. His illustrated talk was punctuated with observations of physical metallurgy research going on in seven institutions in Moscow, Leningrad, and Sverdlovsk.

The Dinner-Dance also featured presentation of awards. Dr. Norbert F. Neuman, Research Supervisor, Uranium div., Mallinckrodt Chemical Works, was awarded the Robert Lansing Hardy Gold Medal for 1958. A $100 award went to Louis J. Kuest, Jr., for his student prize paper, *The Minck Station Anomaly.*

Washington, D. C. section heard Charles H. Johnson of the Bureau of Mines, US Dept. of Interior, at its meeting in the Cosmos Club May 8th. Mr. Johnson spoke on his recent assignment to the United Nations Technical Assistance Administration. Slides helped illustrate his talk. Prior to this assignment, Mr. Johnson had spent two years in India as Mining Advisor to the Indian government.

Niagara Frontier section joined with the Hamilton Branch of the Canadian Institute of Mining and Metallurgy for its Mar. 25th meeting.

The international meeting was preceded by a plant visit to the Carborundum Co., in Niagara Falls, N. Y. Afterward, the meeting moved to the Red Coach Inn, in Niagara Falls, where Leslie Simon, Vice President and Director of the Research and Development div., the Carborundum Co., addressed the gathering *On the Economics of Applied Science in the Corp.*

Mexico section's Apr. 13th meeting heard Luis de la Pena Porth talk on *Los Recursos No Renovables De Mexico.* The Section also heard a progress report from Alfredo Terrazas on the three students that they are sponsoring.

Pennsylvania-Anthracite section held its Spring Meeting in Hazelton, Pa., Apr. 10th. The dinner program dealt with the cutting and transporting of coal hydraulically. C. D. Rubert, Barrett Haentjens & Co., presented a paper entitled *Can Hydraulic Mining Be Applied To The Extraction Of Anthracite?* A second paper entitled *Slurry Pumping* was presented by Walter Haentjens, President of Barrett Haentjens & Co.

Lehigh Valley section held its annual Spring dinner meeting, Apr. 24, in the Hotel Bethlehem, Bethlehem, Pa.

Chairman Nathan Brown, Supt. No. 3 Mine, Bethlehem Cornwall Corp., presided over the meeting attended by 75 members and guests.

Speaker of the evening was AIME member, Warren S. Moore, President of the W. S. Moore Co., Duluth, Minn.

Mr. Moore spoke on *The Mining Chance in Alaska*, and showed slides taken on several of his Alaskan trips.

Eastern section of the National Open-Hearth Steel Committee will be guests of both E. J. Lavino & Co., and G. & W. H. Corson, Inc., at its meeting June 15th.

Members may visit either one or both of the companies. Following the plant visits, lunch will be served at the Plymouth Country Club in Plymouth Meeting, Pa. The day will be topped off with the Eastern section's third annual golf party.

Students' Night enjoyed its annual observance when the **Boston** section of AIME met at the Massachusetts Institute of Technology experimental foundry on March 4th, in joint session with members of the MIT student metallurgical society. Boston section members and students combined forces under the able supervision of Prof. Howard Taylor to prepare their own dinners, utilizing standard foundry facilities.

Following the dinner, the group heard C. H. Hurlbut, Professor of Mineralogy at Harvard University, and presently secretary of the Mineralogical Society of America, discuss *Sources of Exotic Metals.* Reviewing the geographical distribution and availability of a number of the newer metals, Prof. Hurlbut showed how metallurgical require-

ments for materials that will withstand extreme temperatures and corrosive environments have led to evaluation of a number of metals which formerly were ignored. Present limits on the use of these metals were also described.

Papers on Magnetism Invited at Conference

Papers on magnetism and magnetic metals are invited at the Fifth Conference on Magnetism and Magnetic Materials, to be held in Detroit, November 16th to 19th, 1959.

The Conference is being sponsored by the AIEE, in co-operation with The Metallurgical Society of AIME, the Office of Naval Research, the American Physical Society, and the Institute of Radio Engineers.

Manuscripts should be received by August 15th. They should be sent to J. E. Goldman, Scientific Laboratory, Ford Motor Co., P.O. Box 2053, Dearborn, Mich. Instructions to authors, as well as further conference details may be obtained by contracting: D. M. Grimes, Dept. of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

Paris Meeting Invites Gas Metallurgy Papers

Gas in Metals is the theme of this year's Fall Meeting of the Société Francaise de Metallurgie, to be held in Paris, Oct. 19th to 24, 1959.

AIME members are invited to submit papers at this meeting. Subjects will embrace both laboratory studies (determination of gas in metals, effect of gas on properties of metals, and so on), and industrial techniques (oxygen refining, vacuum casting, and other things), according to Max Dupont, the Society's Secretary General.

Southwestern Section of NOHC Holds Annual Spring Meeting

Over 170 registrants gathered at the Lenox Hotel in St. Louis on February 13th for the Annual Spring Meeting of the Southwestern section of the National Open Hearth Steel Committee. The program featured a full day's technical program, a buffet luncheon, supplier's cocktail party, and the Fellowship Dinner.

Dr. W. R. Thorpe opened the program with a report on direct reading and vacuum spectrographs, stressing the economic advantages in terms of both salary savings and savings resulting from more accurate control. E. C. Phillips next presented a paper on hot topping methods. He reported higher yields and better surfaces with exothermic hot tops, but said that some smoke

(Continued on page 412)

WILEY BOOKS

NEW TOOLS FOR THE PROFESSIONAL

1. HIGH TEMPERATURE MATERIALS

Edited by **R. F. HEHEMANN**, Case Institute of Technology, and **G. MERVIN AULT**, National Aeronautics and Space Administration

What's good for use at over 1500°F? The need grows for stable materials at high temperatures, and research is steadily uncovering them. Sponsored by the AIMMPE, a recent symposium reviewed the subject and put what's known on paper, as far as possible. It's in this book, presented by the experts. Unsolved problems are outlined, too, along with the most recent information on current research. CONTENTS: Cobalt and nickel base alloys. Cermets and intermetallics. Refractory metals. Strengthening by dispersion of insoluble particles. Vacuum melting and its effects on properties. Effect of testing environment on properties. Oxidation resistance. **1959. 544 pages. Prob. $17.50**

2. MOLECULAR SCIENCE AND MOLECULAR ENGINEERING

By **ARTHUR R. VON HIPPEL**, Massachusetts Institute of Technology

A revolutionary stride beyond earlier materials engineering studies. Where once the trial-and-error study of existing materials held sway, now you can actually build into your materials safeguards against failures and get true criteria for their ultimate performance—by molecular engineering. A Technology Press book, M.I.T. **1959. 446 pages. $18.50**

3. THE PHYSICAL CHEMISTRY OF STEELMAKING

Edited by **JOHN F. ELLIOTT**, Massachusetts Institute of Technology

Sponsored by M.I.T., a recent symposium dug deeply into a fairly unknown aspect of iron and steel making—its chemistry. The experts assembled summarized current thinking, outlined results of basic research, and presented applications to current technological problems. A Technology Press Book, M.I.T. **1958. 257 pages. $15.00**

4. PHYSICAL LAWS AND EFFECTS

By **C. FRANK HIX, JR.**, and **ROBERT P. ALLEY**, both of General Electric

A convenient, centralized source of information. It's a major step toward making both accepted and unusual laws and effects a practical part of the scientist's approach to his problem. Extensively cross-referenced. **1958. 291 pages. $7.95**

5. PROGRESS IN SEMICONDUCTORS, VOLUME III

Edited by **ALAN F. GIBSON**, Radar Research Establishment, Malvern, U.K.; **R. E. BURGESS**, University of British Columbia; and **P. AIGRAIN**, University of Paris, with 10 contributors.

The latest in your most convenient reference to articles on semiconductors, both here and abroad. Articles are critical reviews on present knowledge and reports on original work. **1958. 210 pages. $8.50**

6. GROWTH AND PERFECTION OF CRYSTALS

Edited by **R. H. DOREMUS, B. W. ROBERTS**, and **DAVID TURNBULL**, all of General Electric Research Laboratories. 51 contributors.

Reports on crystal phenomena, polymer crystallization, and crystallization of simple molecules, presented at an International Conference on Crystal Growth. **1958. 609 pages. $12.50**

7. VOL. IV OF SEMICONDUCTOR ABSTRACTS (1956 issue)

Edited by **E. PASKELL**, BMI.
Compiled by Battelle Memorial Institute, Sponsored by The Electrochemical Society, Inc. **1959. 456 pages. $12.00**

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JM 69

Change of Address and Personals Form

To be sure that you receive your publications and correspondence promptly, please fill in the form below and send it to **The Metallurgical Society of AIME**, 29 W. 39th St., New York 18, N.Y.:

Name _____

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New Address _____

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Personals: Please list below your former company and title and your new title and company (or new work) for use in JOURNAL OF METALS. (Copy deadline for personals items is six weeks before date of issue.)

Former Company _____

Former Title _____ Length of Time There _____

New Company _____

New Company Address _____ Date of Change _____

Any recent activity that would be of interest to members:

_____

_____

_____

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PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

_____

Address

_____

_____

_____

Name of AIME Member:

_____

Address

_____

_____

_____

JM

Southwestern Section

(Continued from page 411)

problems still exist. The morning program was rounded off with a discussion of recent developments in the use of basic refractories by Al Sommer. Steelmen well know that Mr. Sommer was one of the first to advocate use of these materials, and he has been very close to developments for many years.

The afternoon session got underway with a paper on taphole casting and gunning by Ed Goodin. He reported that cast tapholes, using a material containing over 90 pct MgO, had markedly increased taphole life. Fletcher Bonham gave a report on the advantages of ingot mold production in the steel plant; this enables the operator to scarp them economically at an earlier date, giving better overall ingot quality. He also noted that a silicon innoculant increased average mold life from 60 to around 85 heats. Low pouring temperature was stressed as important to mold life.

The final item on the day's program was a symposium on openhearth safety, which consisted of reports of safety programs at nine different plants. Varieties of opinions expressed and results reported stimulated much discussion on this problem which no operator can ignore.

After the Fellowship Dinner, R. O. Criger, editor of Sheffield Division's Ladle, gave a most interesting talk, illustrated with his own slides, on his recent trip to Russia. His experience as a photographer made the pictures far above the average, and his sensitive view of the Russian people provided the audience with many insights into their attitudes and capabilities. All agreed that his was a most outstanding talk.

Personals

(Continued from page 370)

Karl L. Fetters has been named vice president, research and technology, Youngstown Sheet & Tube Co.

Fred A. Kaufman was recently appointed vice president-general manager, Universal-Cyclops Steel Corp., Bridgeville, Pa. He directs sales activities and operation of plants at Bridgeville, Titusville, and Coshocton, Ohio. He was vice president, Refractomet div.

Keith M. McElwain, Alan Wood Steel Co., is the new iron powder technical sales representative for the eastern district. His office is located at Fairfield, Conn.

Samuel A. Ott has been elected vice president, operations, Eastern div., Colorado Fuel & Iron Corp., N. Y. He was works manager, Claymont div., from 1956 until the present.

Richard E. Pawel, recently separated from the military service, has been appointed to the staff of the Oak Ridge National Laboratory.

John D. Saussaman succeeds **Clarence R. Lohrey** as asst. superintendent, Iron & Steel div., Kaiser Steel Corp., Fontana, Calif. Mr. Lohrey has been named consultant to handle special products in the division.

J. C. Spaulding, Sun Oil Co., Dallas, has been elected as the south central region representative of the National Association of Corrosion Engineers. He was formerly a faculty member of Southern Methodist University and has held several offices in the south central region.

George M. Burrier, formerly assistant works manager at Crucible Steel Co. of America's Midland, Pa. works, was recently appointed works manager at the installation.

David Turnbull of the General Electric Research Laboratory, Schenectady, N. Y., was recently awarded an honorary degree of Doctor of Science by Monmouth College, Monmouth, Ill.

In recognition of his outstanding contributions to non-ferrous metallurgical science and to the non-ferrous metals industry, The Institute of Metals (Platinum) Medal has been awarded to **Dr. Leonard Bessemer Pfeil**, director, The Mond Nickel Co. Ltd.

NECROLOGY

Date Elected	Name	Date of Death
1937	Barker, Edgar M.	March 19, 1959
1947	De B. Remy, Marc E.	January 1959
1920	Donoghue, David	Oct. 15, 1958
1935	Green, P. E.	1958
1954	Hartvigsen, L. M.	Unknown
1952	Loeck, Robert E.	January 1959
1955	Parker, H. Leslie	Unknown
1945	Saylor, T. W.	April 7, 1959
1953	Schramm, Harry B.	May 1, 1958
1945	Steward, John C.	Feb. 4, 1959
1955	Szeli, Stephen	Unknown
1893	Tuttle, Arthur L.	Unknown
1957	Walker, W. E.	Unknown

OBITUARIES

Saylor, Thayer W. (member '45) died on April 7, 1959. Mr. Saylor was connected with the International Smelting & Refining Co., Tooele, Utah, from 1927 until his death. After graduating from the University of Kansas with a B.S.Ch.E. in 1927, he took a position with IS&R. In 1936 he became superintendent of cottrells and baghouses. During World War II he was asst. superintendent of the copper plant, later moving up to the position of lead plant superintendent. Mr. Saylor's home was in Tooele.

Zirconium Association Founded in Cleveland By Sixteen Companies

A new organization, the Zirconium Association, with offices in Cleveland, has been formed by 16 companies that produce, melt, and process the metal. Based on the increased importance of and interest in zirconium, the founding companies believe that an association will accomplish a great deal in expanding the uses of zirconium and also establish a focal point from which greater and closer cooperation may be developed between industry and governmental agencies, particularly the Atomic Energy Commission.

Members of the association are: Calumet & Hecla Inc., Wolverine Tube div.; The Carborundum Metals Co., div. of The Carborundum Co.; Carpenter Steel Co.; Columbia-National Corp.; Copperweld Steel Co., Superior Steel div.; Damascus Tube Co.; Firth Sterling Inc.; Harvey Aluminum Co. Inc.; Jessop Steel Co.; Mallory-Sharon Metals Corp.; National Lead Co., Titanium Alloy Mfg. div.; Oregon Metallurgical Corp.; Superior Tube Co.; Tube Reducing Corp.; Universal-Cyclops Steel Corp.; Wah Chang Corp., Zirconium div.

The association office is located at 2130 Keith Building, Cleveland 15, Ohio. Executive director is Mr. W. B. Thomas of Thomas Associates Inc.

Tuttle, Arthur L. (member '93), date of death unknown. Mr. Tuttle graduated from Washington University in St. Louis, Mo., returning as an instructor. His last address was Danville, Ky.

MEMBERSHIP

Proposed for Membership
Metallurgical Society of AIME

Total AIME membership on May 1, 1959 was 31,653; in addition 2,412 Student members were enrolled.

ADMISSIONS COMMITTEE

L. L. Seigle, Chairman; W. L. Brytczuk; F. B. Foley; T. D. Jones; Harold Margolin; Shadburn Marshall.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

Members

Bock, Paul C., Hammond, Ind.
Bokar, Edward J., Cleveland.
Bothwell, Floyd B., Piedmont, Calif.
Butler, Arthur F., Pasadena.
Carr, Hugh B., Carnegie, Pa.
Cramer, Robert F., New York.
Dan, Eli, Hammond, Ind.
De La Pena Porth, Luis, Cerrada de Carracci, Mexico, D.F.
Deuble, Norman L., New York.
Dotlich, Mike, East Chicago, Ind.
Dotson, Clifford L., Houston.
Dugan, John M., Lima, Ohio.
Duval, Leonard A., Aurora, Ohio.
Elder, Byron W., Pittsburgh.
Hires, David D., Youngstown, Ohio.
Hunt, Charles D'A, Richmond, Calif.
Johnston, William G., Schenectady.
Karim, Alexander, Walnut Creek, Calif.
Kratzer, William K., Richland, Wash.
Kretz, Frank J., Munster, Ind.
Styles, Joseph E., Irvona, Pa.
Strommen, Edwin O., Anaconda, Mont.
Turner, Charles A., Jr., Dresher, Pa.
Van Orsdel, John R., Columbus.
Wahli, Marshall J., Columbus.
Wegner, Jack J., Spokane.

Associate Members

Agarwal, Krishna C., Rourkela, India.
Braun, Cyril W., Chicago.
Cassetti, John N., Park Forest, Ill.
Clark, Richard D., Buffalo.
Getlik, Stephen J., Niles, Calif.
Herron, Walter R., Olympia Fields, Ill.
Johnson, Williams H., Jr., Phoenix.
Knight, Clarence A., Tacoma.
Maddock, John K., New York.
Marcec, Ervin, Blue Island, Ill.
Martin, William D., Anaconda, Mont.
Rendall, John W., St. Louis, Mo.
Robinson, Lloyd, Chicago.
Young, Fred R., Seattle.

Junior Members

Besich, Joseph C., Chicago.
Hessler, Barton H., Reading.
McMath, Robert C., Vandergrift, Pa.
Morgan, Royston P., Niagara Falls.
Rippel, Jerry M., Blairsville, Pa.
Sciulli, Charles M., Jr., Monroesville, Pa.
Waite, Gerald H., Pomona, Calif.
Yeh, Tsu-Hsing, Poughkeepsie, N.Y.

REINSTATEMENT

Member

Waterfield, Anthony H., Geneva.

CHANGE OF STATUS

Junior to Member

Smaistrla, Robert N., Houston.

Associate to Member

Deackoff, Leon P., Watertown, Mass.
Johnston, Thomas G., Jr., Lorain, Ohio.
Keiley, George H., Washington, D.C.
Lenning, Gilbert A., Henderson, Nev.
Liu, Tien-Shih, San Antonio.
Mathias, Joseph S., Riverton, N.J.
McEvily, Arthur J., Jr., Langley Field, Va.
Shupe, Kay M., Latrobe, Pa.
Yukawa, Sumio, Schenectady.

Members' Whereabouts Desired by Society

The membership department at AIME headquarters in New York City has been unable to locate the members listed below. Please forward any information concerning these men to H. N. Appleton, AIME Headquarters, 29 West 39th St., New York 18, N. Y.

Date Elected	Name	Last Known Address
1899	Antz, Eugene	Hold Pubs.
1892	Atherton, T. W. T.	Address Wanted
1928	Benwell, Oswald F.	Hold Pubs.
1928	Blumenthal, Hugo	Hold Pubs.
1902	Bradford, Seymour K.	Address Wanted
1900	Comstock, Chas. W.	Address Wanted
1899	Davis, Carl R.	Hold Pubs.
1886	Delano, Frederic A.	Hold Pubs.
1896	Dorion, Fernand J.	Address Wanted
1905	Fox, Jr., Alfred	Hold Pubs.
1928	Franklin, N. E.	Address Wanted
1928	Kroger, Walter W.	Hold Pubs.
1928	Lindsley, Henry D.	Hold Pubs.
1928	Loomis, R. A.	Hold Pubs.
1901	Manners, E. A.	Address Wanted
1928	McClurg, Gilbert	Address Wanted
1898	Morris, James	Address Wanted
1928	Muller-Schall, F.	Hold Pubs.
1928	Parsons, Noel	Address Wanted
1914	Pierce, F. E.	Hold Pubs.
1928	Ramsey, George L.	Hold Pubs.
1887	Reno, Jesse W.	Address Wanted
1897	Richard, George A.	Address Wanted
1928	Richardson, W. E.	Address Wanted
1928	Rodgers, Harry L.	Address Wanted
1928	Shaw, Jr., Percival M.	Hold Pubs.
1914	Sivyer, Leonard D.	Hold Pubs.
1907	Starkey, Tom R.	Address Wanted
1900	Taylor, Albert W.	Address Wanted
1928	Walker, Geo. L.	Hold Pubs.

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DR. E. TSUTSUMI
Registered Japanese Patent Attorney & Consulting Engineer
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Central P.O. Box 1545 Tokyo, Japan

H. L. TALBOT
Consulting Metallurgical Engineer
Extraction and Refining of Base Metals Specializing in Cobalt and Copper
Room 911, 209 Washington St. Boston 8, Mass.

EDWARD G. VOGT
Consulting Chemical-Metallurgical Engineer
Applied Statistics
Experimental Designs Data Analysis
1130 Woodlawn Street, Bethel Park, Pa.
Telephone: TEnnyson 5-5241 (Pittsburgh)

Coming Events

June 5, AIME, NOHC Southern Ohio Section. Golf Outing, Summit Hills Country Club, Fort Mitchell, Kenton County, Ky.

June 10, AIME, NOHC Northern Ohio Section, annual golf party at the Squaw Creek Country Club, Youngstown, Ohio.

June 13, AIME, NOHC Pittsburgh Section, Golf Party, Churchill Valley Country Club.

June 15, AIME, NOHC Eastern Section, plant visit to E. J. Lavino & Co. and G. & W. H. Corson Inc.; golf party at Plymouth Country Club, Plymouth Meeting, Pa.

June 20, AIME, NOHC Cleveland Section, Dinner-Dance, Lake Shore Hotel, Cleveland.

Aug. 23-25, Conference on the Fracture of Engineering Materials (ASM), Rensselaer Polytechnic Institute, Troy, N.Y.

Aug. 31-Sept. 2, AIME Semiconductors Conference, Statler Hotel, Boston, Mass.

Oct. 7-9, Sixth National Symposium on Vacuum Technology of the American Vacuum Society, Sheraton Hotel, Philadelphia.

Oct. 16-17, AIME, NOHC Southern Ohio Section, Fall Meeting, Deshler-Hilton Hotel, Columbus, Ohio.

Sept. 21-22, 57th Fall meeting of the Steel Founders' Society of America, at the Homestead, Hot Springs, Va.

Nov. 2-5, Fall Meeting of The Metallurgical Society of AIME, Morrison Hotel, Chicago.

Nov. 6, AIME, NOHC Pittsburgh Section, Off-the-Record Meeting, Penn-Sheraton Hotel, Pittsburgh.

Nov. 16-20, Conference on Magnetism and Magnetic Materials, Sheraton Hotel, Philadelphia.

Dec. 2-4, AIME 17th Electric Furnace Steel Conference, Hotel Cleveland, Cleveland, Ohio.

Feb. 14-18, 1960, AIME Annual Meeting, Hotel McAlpin and Hotel Statler, New York.

Feb. 16-19, 1960, Symposium on Hydrometallurgy, *Wet Processing of Minerals and Industrial Products,* The Australasian Institute of Mining & Metallurgy, Adelaide, Australia.

Mar. 13-21, 1960, Third International Conference on Nondestructive Testing, Tokyo, Mar. 13-18; Osaka, Mar. 21.

Apr. 4-6, 1960, AIME 43rd National Open Hearth Steel Conference and Blast Furnace, Coke Oven, and Raw Materials Conference, Palmer House, Chicago.

Apr. 21-22, 1960, Southwest Metals and Minerals Conference, Ambassador Hotel, Los Angeles, Calif.

June 13-15, 1960, first International Powder Metallurgy Conference, Hotel Biltmore, New York, under joint auspices of AIME and MPI.

Oct. 17-21, 1960, Fall Meeting of The Metallurgical Society of AIME, Sheraton Hotel, Philadelphia.

Nov. 4, 1960, AIME, NOHC Pittsburgh Section, NOHC, Off-the-Record Meeting.

Nov. 30-Dec. 2, 1960, AIME 18th Electric Furnace Steel Conference, Morrison Hotel, Chicago.

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Downing Industrial Adv. Inc.

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Marschalk & Pratt

Island Creek Coal Sales Co. ..... *
Stockton-West-Burkhart Inc.

Lectromelt Furnace Div. 367
McGraw-Edison Co.
The Griswold-Eshleman Co.

Leitz, Inc., E. ..... *
L. W. Frohlich and Company

Lindsay Chemical Div. 356
American Potash & Chem. Corp.
C. Franklin Brown, Inc.

Marshall Products Co. 409
Weber, Geiger & Kalat, Inc.

Michigan Chemical Corp. 352
Wesley Aves & Assoc.

Molybdenum Corp. of America ..... *
Smith, Taylor & Jenkins, Inc.

Morgan Construction Co. 357
Davis Press, Inc., The

Norton Co. ..... *
James Thomas Chirurg Co.

Ohio Ferro-Alloys Corp. 355
Frease & Shorr Adv.

Philips Electronics, Inc. ..... *
Anders Associates Adv.

Radio Corporation of America 375
Al Paul Lefton Co., Inc.

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Union Carbide Corp.
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Walsh Refractories Corp. ..... *
Ralph Smith Adv. Agency

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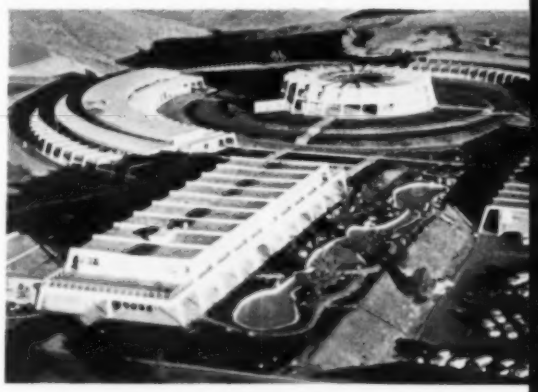

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